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In This Issue

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A Sociometric Measurement of Status in Physical Education Classes

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(Submitted for publication January, 1949)

INTRODUCTION

THERE has been a dearth of sociological investigation in the field of physical education. This situation is partly due to the fact that physical educators have been unfamiliar with the techniques of social research and are therefore prone to consider the social aspect of the program as one of the "intangibles" defying objective measurement. In the field of sociology, however, these "intangibles" have been objectively measured. One of the ways of getting at these phenomena is the sociometric technique devised by J. L. Moreno (5) and his associates. Sociometry gives every evidence of being readily applicable to many physical education problems . This area has been reviewed by Breck (1) and it was concluded that the sociometric test was most suited to the purpose of this study.

STATEMENT OF THE PROBLEM

The purposes of this study were twofold: first, to measure the stability of social judgments of two kinds over a period of seven weeks; second, tc analyze the relationship, if any, between two different kinds of social judgment, i.e., estimates of skill and expressions of friendship.

Specifically, this study attempted to answer the following questions:

1. Is the stability of response affected by the type of activity?
2. How stable are student responses to a sociometric test of skill and friendship?
3. To what degree are judgments about skill and friendship related?

DEFINITION OF TERMS

A sociometric test of the type employed by Moreno (5) and Jennings (3) was adopted for this investigation. The test is defined by Moreno as "An instrument to measure the amount of organization shown by social groups. The sociometric test requires an individual to choose his associates from any group of which he is or might become a member. He is expected to make his choices without restraint" (5).

RELATED LITERATURE

At the time this study was undertaken physical education literature contained studies in which attempts were made to measure the character of students in physical education situations, but no one had tried to measure the social status of the individual within the group or the group's reaction to the individual, or to indicate whether status could be changed. No published physical education studies employed any of the various sociometric techniques.

These techniques have been investigated in the field of sociology and education. Though none of the studies reviewed investigated physical education situations, they are at least indicative of what can be done.

A survey of the literature reveals that the use and application of the sociometric test vary with regard to the number and nature of the specific criteria being tested, and of the specific situations in which it is employed. Further, the number of choices and rejections varies with regard to the problem under investigation.

The validity and reliability of the sociometric test have been indicated in several studies by Cook (2), Jennings (3), Moreno (5), and Zeleny (6). In these studies the coefficients of reliability ranged from +.93 to +.95. In addition, Jennings (4) and others found that individuals do not change from one position to a very different position within the social structure and that these positions are remarkably stable both positively and negatively. Very briefly it can be said that the sociometric test gives evidence of being of practical value for investigation and application in the field of physical education.

As a result of the survey of the literature, five choices were considered suitable for the purposes of this study. Questions pertaining to skill and friendship were chosen as the experimental conditions affecting social status in physical education. Expressions of choice and rejection were requested of the individuals being tested.

METHOD OF PROCEDURE

This study was designed primarily to measure the stability of response on some criteria affecting the social status of an individual in physical education classes.

Subjects.—The sociometric test of social status was administered to five hundred and eighty-six women attending the University of California at Los Angeles during the fall semester of 1945. The semester was sixteen weeks in length, and the classes met three times a week. The various groups consisted of both resident and non-resident women whose ages ranged from seventeen to twenty-five years. Samples were taken of individual, team, and rhythmic activities. The women were measured in four beginning swimming classes, six volleyball classes, and five dance fundamentals classes.

Test Form.—The students were requested to make five positive choices and five negative choices on the basis of skill and friendship. Wording on the questionnaire differed according to the activity in which the individual was being tested. Briefly the questions were as follows:

Form A[1]: Please print in the order of preference the names of the 5 girls you would *most* prefer to have on your swimming team. *(Skill)*
————the 5 girls you would *least* prefer to have on your swimming team. *(Skill)*
Please print in order of preference the names of the 5 girls you would *most* prefer to have as friends, whom you would invite to your home. *(Friendship)*
————the 5 girls you would *least* prefer————. *(Friendship)*

Testing Sequence.—The procedure followed in this study began with a five-week period in which the instructors of the various classes were requested to stress that all the students in the classes become acquainted. The sociometric test was administered during the sixth (Test I), twelfth (Test II), and thirteenth week (Test III) of the semester.[2]

SCORING

In an effort to answer the problems with which this study was concerned, it was necessary to investigate several methods of tabulating the results of the sociometric test. In handling the data four methods were used:

1. Tabulating only expressions of choice, assigning 1 point to each choice expression. (Mary Jones received 5 expressions of choice. Score: 5.)

2. Tabulating expressions of choice and subtracting expressions of rejection. (Mary Jones received 5 choices and 2 rejections. Score: 3.)

3. Tabulating only expressions of choice which were weighted by arbitrarily assigning a score of 5 to first place, 4 to second, 3 to third, 2 to fourth, and 1 to fifth place. (Mary Jones received 5 choices: 2 first-place choices (10); 2 second-place choices (8); and 1 fifth-place choice (1). Score: 19.)

4. Tabulating expressions of choice and subtracting expressions of rejection. The choice and rejection reactions were weighted as above. (Mary Jones received 5 choices: 2 first, 2 second, 1 fifth (19); and 2 rejections: 1 first, 1 second (—9). Score: 10.)

The technique used in evaluating the four methods of scoring consisted of comparing the coefficients of correlation of the scores

[1] Wording for forms B and C, volleyball and dance, of necessity varied slightly from form A with the students listing choices for people they would prefer on a volleyball team and in a dance study.

[2] An acquaintance volume test was administered along with the sociometric test but was not analyzed in this study.

on Test II with the scores on Test III. Coefficients of correlation were obtained by means of the Spearman Rank Difference Method. The assumption was that the scoring method yielding the highest consistency would be superior. The differences between these obtained correlations were not significant.[3] For this reason the weighting technique, which is more difficult and more time-consuming for practical purposes, was not used in this study.

The use of unweighted choices minus unweighted rejections was selected as the method for tabulating results in this study. It is a method which can be easily administered and computed. This procedure was selected for it is the tendency in sociometric research to consider expressions of rejection important for both scientific and practical purposes because expressions of rejection give a more complete picture of the actual group structure. The use of unweighted choices without rejections could be justified on the basis of the data.

FINDINGS

Reliability.—The related literature indicates clearly enough that responses to sociometric tests can have high reliability; therefore, this paper has not attempted to defend the proposition of reliability. Because the time interval between Test II and Test III ($T_{II}T_{III}$) was reduced to a minimum, the reader may refer to those correlations as expressions of reliability. (See Tables I and II, Skill $T_{II}T_{III}$ and Friendship $T_{II}T_{III}$). Generally, these data support the findings of previous sociometric investigations for physical education situations. They reveal that the test is equally reliable in all situations in which it is employed when skill or friendship is the criterion.

Type of Activity and Stability.—In every instance there was no significant difference between the coefficient of correlation of one type of activity when compared with another type of activity when either skill or friendship was the condition under investigation. Two estimates of stability were made. (See Tables I and II.) Test I was correlated with Test II ($T_{I}T_{II}$), and Test I with Test III ($T_{I}T_{III}$) representing six- and seven-week intervals. Estimates were made for both skill and friendship scores. The mean correlations of the skills scores for the six-week period were as follows: (1) swimming, $.67\pm.04$; (2) dance, $.70\pm.03$; (3) volleyball, $.72\pm.02$. Over the seven-week period the mean correlations for skill were as follows: (1) swimming, $.68\pm.02$; (2) dance, $.69\pm.03$; (3) volleyball, $.64\pm.04$. The statistics indicate that during both the six- and seven-week periods the individuals tested did not tend to change their status to any marked degree in any of the activities.

When friendship is the criterion of status, the mean coefficients of correlation over the six-week period were as follows: (1) swim-

[3] For the purposes of this experiment the .05 level was considered significant.

TABLE I

CORRELATIONS BETWEEN TESTS I, II, AND III FOR SKILL, FRIENDSHIP, AND SKILL-FRIENDSHIP

Class Section	Number Cases	Skill T_IT_{II}*	Skill T_IT_{III}	Skill $T_{II}T_{III}$	Friendship T_IT_{II}	Friendship T_IT_{III}	Friendship $T_{II}T_{III}$	Skill-Friendship T_IT_I	Skill-Friendship $T_{II}T_{II}$	Skill-Friendship $T_{III}T_{III}$
Dance										
19	30	.740±.06	.654±.07	.83±.04	.677±.07	.674±.07	.740±.06	.654±.07	.433±.10	.508±.10
20	29	.886±.03	.795±.05	.945±.01	.809±.05	.734±.06	.798±.05	.735±.06	.716±.06	.638±.08
22	29	.587±.09	.774±.05	.694±.07	.745±.06	.771±.05	.787±.05	.320±.12	.413±.11	.705±.07
23	29	.765±.05	.779±.05	.881±.03	.410±.12	.361±.11	.836±.04	.597±.08	.127±.13	-.010±.13
24	33	.403±.10	.441±.10	.879±.03	.442±.10	.453±.10	.753±.05	.642±.07	.517±.09	.543±.09
Swim										
44	28	.863±.03	.831±.04	.882±.03	.688±.07	.791±.05	.861±.03	.744±.06	.823±.04	.794±.05
45	25	.848±.04	.845±.04	.900±.03	.842±.04	.868±.03	.859±.04	.435±.11	.276±.13	.442±.11
46	29	.423±.11	.514±.10	.888±.03	.564±.09	.584±.09	.580±.09	.629±.08	.310±.12	.331±.12
48	33	.527±.09	.361±.11	.914±.02	.375±.11	.478±.10	.800±.04	.434±.10	.443±.10	.553±.09
Volleyball										
60	56	.744±.04	.765±.04	.903±.02	.824±.03	.707±.05	.810±.03	.663±.05	.908±.02	.657±.05
61	52	.594±.06	.544±.07	.904±.02	.576±.07	.585±.06	.752±.04	.541±.07	.399±.08	.528±.07
62	54	.602±.06	.597±.06	.820±.03	.744±.04	.569±.06	.717±.05	.481±.07	.270±.09	.461±.08
63	54	.834±.03	.726±.05	.876±.02	.688±.05	.735±.04	.841±.03	.568±.07	.547±.07	.493±.07
64	52	.800±.04	.709±.05	.859±.03	.666±.05	.500±.07	.780±.04	.571±.07	.498±.07	.444±.08
65	54	.766±.04	.725±.05	.943±.01	.692±.05	.668±.05	.772±.04	.461±.08	.570±.06	.377±.08

*T_I, Test administered in 6th week; T_{II}, Test administered in 12th week; T_{III}, Test administered in 13th week.

TABLE II

MEAN CORRELATIONS BETWEEN TESTS I, II, AND III FOR SKILL, FRIENDSHIP, AND SKILL-FRIENDSHIP*

Number Cases	Skill T_IT_{II}	Skill T_IT_{III}	Skill $T_{II}T_{III}$	Friendship T_IT_{II}	Friendship $T_IT_{II^I}$	Friendship $T_{II}T_{III}$	Skill-Friendship T_IT_I	Skill-Friendship $T_{II}T_{II}$	Skill-Friendship $T_{III}T_{III}$
Dance 150	.669±.03	.686±.03	.845±.02	.616±.04	.598±.04	.783±.02	.589±.04	.441±.05	.476±.05
Swim 114	.665±.04	.637±.04	.896±.01	.617±.04	.680±.04	.775±.03	.560±.05	.463±.05	.530±.05
Volleyball 322	.723±.02	.677±.02	.884±.01	.698±.02	.627±.02	.778±.02	.547±.03	.532±.03	.493±.03
Total 586 Mean	.689±.02	.661±.02	.874±.006	.649±.02	.631±.02	.779±.01	.565±.02	.483±.02	.430±.02

* Mean correlations on this table were obtained by averaging correlations reported on Table I.

ming, .70±.02; (2) dance, .62±.04; (3) volleyball, .62±.04. The results of the seven-week period were as follows: (1) swimming, .68±.04; (2) dance, .60±.04; (3) volleyball, .64±02. An inspection of the data reveals that over the six- and seven-week periods there was not a significant shifting of positions in any of the three activities.

In every instance there was no significant difference between the mean coefficients of correlation of one type of activity when compared with another type of activity when either skill or friendship was the condition under investigation.

Stability of Skill and Friendship.—An analysis of the above data and of Tables I and II indicates that there is no significant difference between the stability of response when either skill or friendship is involved. In fact, individuals do not shift from one position to a very different position when either skill or friendship is the criterion of status under consideration.

Relationship Between Skill and Friendship.—The coefficients of correlation on skill-friendship ranged from .43±.02 to .57±.02. On both Tables I and II the three types of activities do not differ significantly in the size of their correlations, nor do the correlations show a significant difference in the three administrations of the test. These statistics show for the subjects of this study that, although an individual may attain a certain social status when skill is the criterion, that person does not necessarily have a similar position when friendship is the status condition being considered. The data indicate that the students display ability to differentiate in their judgments concerning skill and friendship in being capable of distinguishing between the two criteria.

SUMMARY AND CONCLUSIONS

In summary, an analysis of the literature indicates that the sociometric method of measuring status gives evidence of being applicable to physical education. This is further supported by the findings in this study. Of the four methods which were employed to compute the data, two were found to be of practical value: (1) Tabulating only expressions of choice, assigning one point to each choice expression; (2) tabulating expressions of choice and subtracting expressions of rejection, assigning one point to each choice expression and subtracting one point for each expression of rejection. The data support previous sociometric studies which indicate that the sociometric test has high reliability.

The investigation of the stability of response indicates that during both six- and seven-week periods the responses tended to remain equally stable for both skill and friendship in all the types of activity under investigation. This means that when skill and

friendship are the criteria of status the individuals being tested do not change their positions significantly over a six- or seven-week period, or that an individual does not in general tend to alter his status from one position to a very different position.

In attempting to discover whether there is any relationship between skill and friendship as factors affecting status, the statistics disclose that there is a low positive correlation between the two. This may indicate that the students seem to differentiate between the two conditions affecting status.

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The Effect of Systematic Weight Training on Power, Strength, and Endurance

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(Submitted for publication August, 1949)

WHENEVER weight training[1] is discussed, it almost invariably gives rise to the expression of extremely controversial opinions. Its promulgators may go so far as to claim it a panacea of all ills, while its denunciators may not hesitate to set forth its deleterious effects.

Hoffman (7) states that weight training is the most effective form of physical training for both visceral, skeletal, and muscular development. He believes that exercise with weights produces an optimum physical condition in a minimum of time.

Many coaches, especially those concerned with swimming and track events, believe that exercise with weights produces *muscle-tightness*[2] and a decrease in speed.

However, neither the claims for, nor those against, weight training have been fully substantiated. Hence this study has been undertaken in an attempt to determine effects of systematic weight training on strength, on athletic power, and on muscular and circulo-respiratory endurance.

A REVIEW OF THE LITERATURE

In almost any discussion of weight training the name of Hoffman[3] looms large. This fact is undoubtedly due to the extravagant claims made by Hoffman in a vast amount of writing that he has published for public consumption. Although he has not produced any documented evidence for his conclusions, a review of the literature relative to weight training would be incomplete without reference to him.

The only study of a scientific nature relative to the effects of weight training *per se* that the writer found in the literature was that by Chui (1) who investigated effects of weight training on athletic power. Twenty-three weight-training subjects and twenty-

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The writer wishes to express his sincere appreciation and indebtedness to Dr. Norma D. Young and Dr. C. H. McCloy for their guidance and helpful suggestions throughout this study.

[1] The term *weight training* as used in this study denotes a routine of calisthenics performed with bar bells and dumbbells.

[2] *Muscle-tightness,* often referred to as *muscle-boundness,* an equally vague term, usually denotes a short bulky muscle.

[3] Robert Hoffman is the owner of the York Barbell Company and also publishes the magazine *Strength and Health.*

two control subjects, all selected from the required physical education classes at the University of Iowa, were used in this study. The classes met for fifty minutes of activity twice a week for a period of three months. Chui tested the groups at the beginning and at the end of the term with the following tests: (1) Sargent jump-standing, (2) Sargent jump-running, (3) standing broad jump, (4) eight-pound shot-put from a stand, (5) twelve-pound shot-put from a stand, and (6) sixty-yard sprint.

Chui found that the weight trainers showed a greater increase in all events than did the control group. He did not, however, compute the t-statistics to show at what level of significance the differences existed.

A chapter concerned with physiological facts and psychological implications relative to weight training was included. One rather important psychological implication, however, was not discussed. It is the feeling of this writer, based on his experience, that strong motivation, determination, or belief in self greatly aid in the achievement of a maximum amount of strength. To substantiate this statement, reference is made to Steinhaus' statement that "the unusual feats of strength which can be performed by people of ordinary development, when in hypnotic states or when excited, suggest that strength may also in part be learned" (12, p. 138).

Secondary evidence of the effects of exercising specific muscle groups with increasingly heavier weights is found in the publications of De Lorme (2, 3, and 4) and in the thesis of Clayton Henry (6). In these studies, it was found that the systematic lifting of progressively heavier weights greatly increased muscular strength and endurance.

McCloy has published a theoretical treatise on the whole problem of endurance, which is pertinent to this study; hence this aspect of the question will not be discussed in detail here (11). In brief, McCloy suggests that, as far as pure muscular function is concerned:

1. An increase in muscular strength (by hypertrophy) will result in fewer motor units being required for lifting a given load; hence the smaller number of motor units may be alternated for a longer period of time.

2. Since overload for muscular endurance is commonly held to result in the development of a more adequate blood supply to the muscle *as well as* facilitate increase in strength of the muscle, the greater oxygen supply brought by this increased blood supply should improve muscular endurance.

3. Circulo-respiratory endurance may be increased by (a) increasing the strength and muscular endurance of the muscles concerned (e.g., the muscles concerned with running), and by (b) im-

proving, by hypertrophy and increased capillary supply, the strength and muscular endurance of the heart itself.

The above account indicates the paucity of controlled studies published in the area of weight training.

PROCEDURE

Subjects.—Two groups of students were used in this study. One group, which will be referred to hereafter as Group A, was a weight-training class of sophomores at the University of Tennessee. The other group, which will be referred to hereafter as Group B, was a conditioning class of freshmen at the same university. Both groups met twice a week for eleven weeks. The second, third, twentieth, and twenty-first class periods of the eleven-week period were devoted to the testing involved in this study.

The average age of Group A was one year greater than that of Group B. As would be expected, the average weight was also slightly higher for Group A than for Group B.

Since Group A had for one year engaged in the very strenuous training of the freshman required physical education program, they were also stronger and had greater endurance than Group B. This disparity was unavoidable in the situation used for this study.

Group A was comprised of forty-two students. Only one student in this group had had any previous experience in weight training.

Conditioning Program.—Group A's forty-minute class periods were devoted wholly to weight-training exercises. One bar bell and two pairs of dumbbells were supplied to each group of four students. With diligent utilization of the forty minutes, the students were all able to complete all the exercises of the routine.

The following bar bell and dumbbell exercises (14, p. 67) were used by Group A:

1. High pull-up
2. Two-arm curl
3. Side bend
4. Two-arm press
5. Two-hand repetition snatch
6. Stiff-leg dead lift
7. Supine press
8. Sit-up
9. Squat jump
10. Supine pull-over
11. Lateral raise
12. Front raise
13. Lateral raise with trunk bent
14. Lateral raise in supine position

A weight that could be curled a maximum of eight times was used for exercises one, two, and three. After the completion of these three exercises, weight was added so that no more than eight presses could be accomplished. This weight was then used for exercises four and five. This same method of adding weight also applied to the supine press, and the resultant weight was used for exercises six and seven. Ten-, fifteen-, or twenty-pound dumbbells

were utilized for exercises ten, eleven, twelve, thirteen, and fourteen. A weight that allowed eight repetitions was chosen.

After selecting the correct weight for the above exercises, the student continued to use this weight until he attained fifteen repetitions, at which time he again selected a weight that allowed only eight repetitions.

In selecting a weight for sit-ups, the student determined the heaviest weight with which he could sit up twenty to twenty-five times. Upon attaining fifty sit-ups with this weight, he started over as he had done with the bar bell exercises.

A pair of ten-, fifteen-, or twenty-pound dumbbells was used for squat jumps. Starting with a pair of ten-pound dumbbells, the student trained until he achieved thirty-two squat jumps, at which time he changed to a heavier pair of dumbbells.

Group B was composed of twenty-nine members. With the exception of six periods spent in orientation and in testing, Group B participated for forty minutes each period in a conditioning course. It should be noted that the course for Group B was a very strenuous conditioning course. An outline of this course[4] is as follows:

1. Tumbling, bag relays, and running (two weeks).
2. Lifts and carries, hand combats, and running (three weeks).
3. Conditioning gymnastics (five weeks).

Administration of Tests.—The test items appearing below constitute the batteries of tests administered both at the beginning and at the end of the eleven-week period.

Muscular Strength: The strength index (McCloy's revision), (10, p. 30) which includes the following items, was used as a measure of muscular strength: Right grip, left grip, back lift, leg lift, chinning, dipping on parallel bars.

Muscular Endurance: The following items were used as a measure of muscular endurance (14, p. 243): Chinning, push-ups, sit-ups (2 minutes), squat jumps.

Circulo-respiratory Endurance: The 300-yard shuttle run was used as a measure of circulo-respiratory endurance (13, p. 337).

Athletic Power: The following items were used as a measure of athletic power (9): Standing broad jump, standing Sargent jump, running Sargent jump, eight-pound shot-put.

On the first day of the initial testing and of the final testing the muscular strength and the circulo-respiratory endurance events were administered. On the second day of the initial and of the final testing the muscular endurance and the athletic power events were administered. The writer and three trained assistants administered the tests according to the standard instructions. Three trials were allowed, and the best one was recorded.

[4] A detailed list of these exercises may be found in the appendix.

For the majority of the test items there was no practice between the initial and the final testing. Group A practiced squat jumps and sit-ups, for these exercises were included in the weight-training routine. Group B practiced chinning, sit-ups, and the 300-yard shuttle run, for these events were included in the conditioning course.

ANALYSIS OF RESULTS

The changes in weight, in muscular strength, in muscular endurance, in circulo-respiratory endurance, and in athletic power between the test results at the beginning and at the end of the eleven-week period are discussed below.

Weight.—Both Group A and Group B increased in body weight; however, Group A increased slightly more than Group B. These findings, together with the percentages, are shown in Table I.

TABLE I

WEIGHT (POUNDS)

	Group A			*Group B*		
	Initial Mean	*Final Mean*	*Gain %*	*Initial Mean*	*Final Mean*	*Gain %*
Weight	160.26	162.62	1.4	152.21	153.48	.8

Muscular Strength.—The findings for the individual muscular strength tests, together with the percentages, t-statistics which were computed from the raw scores (8, p. 138), and significant levels are shown in Table II.

Group A and Group B both increased in the muscular strength events. Group A's increases in left grip, leg lift, chinning, and dipping were greater than Group B's. Group B's gains in right grip and back lift exceeded the gains of Group A.

There is some question in the writer's mind with reference to the results of the back lift. Inasmuch as there are several possibilities of error in measurement in this test[5] and because of the fact that the variability was quite large some doubt arises as to the accuracy of the measurements of this test item.

The muscular strength events were also grouped and converted to the Physical Fitness Index or quotient type of scores (10, p. 26). These scores were averaged for each group, and the percentages of gain, the t-statistics which were computed from the P.F.R. scores, and the levels of significance were computed. From combining these tests and thereby raising the reliability, the difference in gain is altogether in favor of Group A, at a two percent level of significance. These findings are shown in Table III.

Muscular Endurance.—The findings for the individual muscular

[5] In the measurement of the back lift, a very slight bend in the knees can cause the record to be considerably greater than would be the case were the knees straight. Al o a weak grip strength or "sweaty" hands may not allow the full back pull to be performed, and may result in an inaccurate measurement of the back strength.

TABLE II

Individual Events

		Group A			Group B					
		Initial Test	*Final Test*	*Gain %*	*Initial Test*	*Final Test*	*Gain %*	*Difference in Gain, %*	*t*	*Significance at*
Right Grip	Mean	122.83	124.69	1.5	115.28	120.52	4.5	–3.0	1.60	10% level
	Mdn.	125.77	127.50	1.3	119.00	119.00	0.0	1.3	....	....
Left Grip	Mean	109.10	112.76	3.3	106.34	106.90	.5	2.8	1.96	5% level
	Mdn.	110.00	116.54	5.3	111.47	112.85	1.2	4.1	....	....
Back Lift	Mean	438.33	454.88	3.8	386.55	405.34	4.8	–1.0	.17	85% level
	Mdn.	429.69	455.35	5.9	409.09	422.22	3.2	2.7	....	....
Leg Lift	Mean	944.52	1270.23	34.8	906.14	1097.58	21.1	13.7	2.34	2% level
	Mdn.	921.43	1290.00	39.9	900.00	1100.00	22.2	17.7	....	....
Chinning	Mean	8.12	10.57	30.1	6.14	7.86	27.9	2.2	1.64	10% level
	Mdn.	8.68	10.62	22.3	6.00	8.25	37.5	–15.2	....	....
Dipping	Mean	8.31	11.48	38.1	6.07	7.07	16.4	21.7	3.76	Less than 1% level
	Mdn.	9.22	11.72	27.1	5.66	7.66	35.3	–8.2	....	....
Push-ups	Mean	24.45	30.05	22.9	21.10	27.69	31.2	–8.3	1.44	15% level
	Mdn.	25.89	30.00	15.8	22.85	28.33	23.9	–8.1	....	....
Sit-ups	Mean	41.02	50.95	24.2	28.72	47.07	63.8	–39.6	4.03	Less than 1% level
Two minutes	Mdn.	37.50	50.48	34.6	31.11	50.00	60.7	–26.1	....	....

TABLE II (Continued)

INDIVIDUAL EVENTS

		Group A Initial Test	Group A Final Test	Group A Gain %	Group B Initial Test	Group B Final Test	Group B Gain %	Difference in Gain, %	t	Significance at
Squat Jumps	Mean	34.19	55.05	61.0	31.41	44.83	42.7	18.3	2.89	Less than 1% level
	Mdn.	34.42	54.06	57.0	30.00	45.71	19.0	38.0	....	....
300-Yd. Dash	Mean	1'8"	1'4"	6.2	1'10.2"	1'6"	6.3	−0.1	.78	45% level
	Mdn.	1'8.5"	1'5"	5.4	1'10.2"	1'6"	6.8	−1.4	....	....
Standing Broad Jump	Mean	6'8"	7'1"	6.0	6'9.6"	6'10"	1.4	4.6	3.40	Less than 1% level
	Mdn.	6'9.5"	7'3.3"	7.1	6'10.5"	6'10"	−0.6	6.5	....	....
Sargent Jump	Mean	48.33	54.69	13.1	48.14	53.21	10.5	2.6	.78	45% level
	Mdn.	49.04	56.25	14.7	49.44	54.00	9.2	5.5	....	....
Running Sargent Jump	Mean	52.86	58.60	10.8	53.17	57.76	8.6	2.2	.66	50% level
	Mdn.	53.50	59.64	11.4	54.29	58.88	8.4	3.0	....	....
8-pound Shot	Mean	31'11"	34'6"	8.1	30'6.2"	31'9.6"	4.5	3.6	1.99	5% level
	Mdn.	31'9"	35'0"	10.2	31'0"	33'0"	6.5	3.7	....	....

endurance events, together with the percentages, t-statistics which were computed from the raw scores, and levels of significance are shown in Table II.

Both Group A and Group B increased in all muscular endurance events. Group A increased more than did Group B in chinning, dipping, and squat jumps. Group B increased more than did Group A in push-ups and two-minute sit-ups.

The large gain by Group A in squat jumps may be due, in part, to the practicing of this event in the class routine; however, Group B also practiced another type of squat jumping exercises in the moving gymnastics phase of the program.

TABLE III

MUSCULAR STRENGTH[1]

	Group A			Group B					
	Initial Test	*Final Test*	*Gain %*	*Initial Test*	*Final Test*	*Gain %*	*Difference in Gain, %*	*t*	*Significant at*
Mean	102.7	107.5	4.6	101.5	104.3	2.7	1.9	2.31	2% level
Mdn.	102.5	107.5	4.8	102.6	104.0	1.3	3.5	....	....

TABLE IV

MUSCULAR ENDURANCE[2]

	Group A			Group B					
	Initial Test	*Final Test*	*Gain %*	*Initial Test*	*Final Test*	*Gain %*	*Difference in Gain, %*	*t*	*Significant at*
Mean	220.4	267.8	21.0	189.5	235.9	24.5	−3.5	.685	50% level
Mdn.	225.5	261.0	15.7	192.5	236.6	22.8	−7.1	....	....

[1] The individual strength events were grouped and converted to P.F.I. type of scores for this table.

[2] Each item (chins, dips, push-ups, sit-ups, and squat jumps) was scored on the scoring tables in *The Iowa Program of Physical Education for Boys*, p. 243, and the scores thus obtained were totaled.

While Group B surpassed Group A in the gain in two-minute sit-ups, attention should be called to the fact that the initial records of Group B were lower than those of Group A. Hence, in order to approach peak performances, Group B had a greater opportunity for gain than Group A had. In addition to the applicability of this fact for accounting for the difference in gains in push-ups, this test item was included in Group B's program of calisthenics.

In the combination of the scores for the individual muscular endurance events, (14, p. 243) Group B showed a greater percentage of gain than did Group A. However, the actual gain was very nearly the same for both groups, and it is re-emphasized that Group B started wtih much lower scores than Group A, which fact offered the greater distance for improvement for Group B.

The findings for the combined muscular endurance events are shown in Table IV.

Circulo-respiratory Endurance.—The findings for the circulo-respiratory endurance test, together with the percentages, t-statistic which was computed from the raw scores, and level of significance are shown in Table II. It can be seen that both Group A and Group B improved very nearly the same amount.

Athletic Power.—The findings for the individual athletic power tests, together with the percentages, t-statistics which were computed from the raw scores, and levels of significance are shown in Table II.

With one exception, both Group A and Group B increased in the athletic power events. Group B failed to improve in the standing broad jump. In every case Group A improved more than did Group B, and in the power events both groups started with nearly the same mean score.

The athletic power events were T-scored and the T-scores totaled. This procedure tends to raise the reliability of the whole battery, as contrasted with the reliabilities of the individual tests (5, p. 388). The total of the T-scores also supplied the total gain, and the level of significance for the combined power events. The findings for the combined power events are shown in Table V.

TABLE V

ATHLETIC POWER[1]

	Group A			Group B					
	Initial Test	*Final Test*	*Gain %*	*Initial Test*	*Final Test*	*Gain %*	*Difference in Gain, %*	*t*	*Significant at*
Mean	45.4	52.2	14.9	45.8	48.7	6.3	8.6	2.14	2% level
Mdn.	47.4	53.4	12.7	45.2	50.3	11.3	1.4	....	....

[1] The individual power events were T-scored and the T-scores totaled before the t-statistics of this table were computed.

DISCUSSION

The fact that the two groups were not completely equivalent should be kept in mind in considering the significance of the findings, discussed above. Group A usually was slightly better than Group B at the beginning of the training period. Since improvement curves for those in moderately good condition are usually convex above, it might be assumed that equivalent improvement at higher levels would probably be more difficult and, hence, more significant.

It is well known that the use of overloads of weight produces hypertrophy of muscle and increase in strength. While generally undocumented, this is also the common experience of those who have participated in teaching or practicing weight-training programs.

It is also well known that an overload of muscular endurance exercises (e.g., progressive practice of chinning) will increase muscular endurance, while an overload of distance running will increase circulo-respiratory endurance. These facts are also confirmed by this study. We have found no published data in the recent literature, however, on the effects of exercise consisting of overloading with weights (weight training) on the development of muscular and circulo-respiratory endurance. If McCloy's theories are correct, there should be a direct effect on improving muscular endurance, and on improving that part of circulo-respiratory endurance, but not on the improvement of the heart function.

SUMMARY OF FINDINGS

As would probably be expected, the Group A program gave greater general improvement in muscular strength than did the Group B program.

There were no significant differences between the two groups in the improvement in muscular endurance or in circulo-respiratory endurance. It is of interest, however, to note that Group A excelled Group B in all final scores, though the significance of this may be doubtful, due to the differences in the initial scores.

In the power events, however, Group B had an initial test that averaged higher than that of Group A; yet, Group A improved significantly more in these "speed events" than did Group B. Also, it should be noted that there was no practicing of this kind of event in Group A, while there was practice in Group B. Hence, it seems that the results of this experiment would point to the probability that weight training, at least when limited to the extent to which it was used here, does not result in muscular tightness and in a decrease of speed of muscular contraction as is commonly assumed. It seems to have been *as effective* in the development of muscular and circulo-respiratory endurance as was the program of Group B, which especially emphasized these endurance elements.

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Appendix

Detailed List of the Exercises Employed for Group B

1. Tumbling, Bag Relays, and Running (4 class periods)
   a. Calisthenics (7 minutes).
   b. Stunts and tumbling (12 minutes).
   c. Bag relays with 40-pound bags (15 minutes).
   d. Running (3 minutes).
2. Lifts and Carries, Hand Combats, and Running (5 class periods)
   a. Calisthenics (7 minutes).
   b. Carries (16 minutes): Fireman's carry, cross carry, single-shoulder carry, arm carry.
   c. Hand combats (10 minutes): Strength and agility events.
   d. Running (3 minutes).
3. Conditioning Gymnastics (7 class periods)
   a. Grass drills (4 minutes).
   b. Moving gymnastics (24 minutes): High kick, bear walk, circle walking, lame-dog walk, rabbit hop, crab walk, inverted drag, stiff-knee walk, measuring worm, seal walk, leg-straddle hop, mermaid walk, camel walk, jump to squat, duck waddle.[a]
   c. Practice P. F. R. test items (10 minutes): Sit-ups, chins, shuttle run.

[a] A detailed description of these exercises may be found in the War Department Field Manual, *Physical Training, FM 21-20.*

A Statistical Evaluation of Physical Fitness Tests

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INTRODUCTION

MUCH research has been undertaken to investigate the relationship between cardiovascular functions and general bodily efficiency, and the use of this relationship to gauge general health has brought forth a wide variety of tests which vie for recognition. Workers in the fitness field have often been puzzled by the low correlation shown between tests which all purport to measure this general trait.

This study which was carried out at the Naval Submarine Base, New London, Connecticut, attempted to separate the similarities and dissimilarities underlying measurements derived from several such tests, all of which have found support in one or more of the services:

Behnke Step-up Test.—Developed by members of the Experimental Diving Unit, Washington, D. C. (1), this test is employed in the selection of candidates for Deep-Diving School. It has two distinct components. In practice, it is recommended that phase (a) be used for frequent fitness checks, and phase (b) only occasionally. Both sections were employed in this study.

(a) Cardiovascular phase: This consists of 20 step-ups in 30 seconds on a stool 18 inches high. The sitting pulse is counted prior to the exercise, and pulse rate counts are taken during the periods 5-20″ and 105-135″ after completion of the step-ups. The cardiovascular score is computed as the total of the two post-exercise pulse rates. This scoring method provides a range of values between 54 (good) and 90 (poor), or a difference of 36 heart beats for interpreting scores.

Opinions or conclusions contained in this paper are those of the authors and are not to be construed as necessarily reflecting the views or the endorsement of the Navy Department. Since the paper was submitted for publication Comdr. Cook has been transferred to Tufts College Medical School, Boston, Mass.

(b) Endurance phase: This consists of the same exercise as in phase (a) but continued until exhaustion or loss of pace forces cessation. As an aid to uniform motivation in this study, the medical officers administering the tests established a 5-minute cut-off point. The pulse rate was counted during the 5-20″ period following the endurance run. Although in actual use, a post-endurance pulse rate under 140 is considered inconsistent with maximum effort (1), the score for phase (b) is recorded simply as the endurance time in seconds, and the minimum satisfactory score is 60 seconds (1).

Harvard Step-up Test.—This test which has been introduced into the Navy and Army aviation training programs consists of 30 step-ups in 60 seconds on a stepping platform 20 inches high for a period of 5 minutes. In addition to the customary post-exercise pulse measures (1-1½, 2-2½ and 3-3½ minutes following the endurance run), the 5-20″ pulse rate following the exercise was taken for purposes of this study. However, the score was computed according to the prescribed formula (2):

$$\text{Score} = \frac{\text{duration of exercise in seconds} \times 100}{2 \times \text{sum of pulse counts } 1\text{-}1\tfrac{1}{2}',\ 2\text{-}2\tfrac{1}{2}',\ 3\text{-}3\tfrac{1}{2}' \text{ in recovery}}$$

For military purposes, Harvard suggests (2) the following interpretation of scores: below 55 indicates poor physical condition; 55-64, low average; 65-89, average; 80-89, good, and 90 plus, excellent.

Schneider Index of Physical Fitness.—One of the earliest of the comprehensive cardiovascular tests, the Schneider has remained popular with the Army and Navy air forces, and is coming into increasing use by civilian airlines as part of their pilot fitness programs. It consists of 5 step-ups in 15 seconds on a stool 18½ inches high. Many pulse and blood pressure counts are taken (3) and the final score is the algebraic sum of values given the following separate points: reclining pulse rate, pulse rate increase on standing, standing pulse rate, pulse rate immediately after exercise, return of pulse rate to standing normal after exercise, and systolic pressure standing compared with reclining.

The Medical Department of the Navy regards a score of 7 or less as disqualifying for flight-training candidates if the score remains at this point after repeated administration of the test (4). Further, systolic blood pressure which persistently exceeds 135 mm. and a diastolic pressure constantly in excess of 90 mm. is unacceptable (4).

Hand Dynamometer.—Dynamometers have been employed to assess various aspects of muscular strength for more than 50 years, and a test of hand strength was added to this study for its possible

relation to the fitness tests. A Smedley dynamometer was employed according to the technique of Fisher and Birren (5). The essential characteristic of the procedure is that the subject squeezes on the dynamometer at regular intervals, increasing the force exerted by a constant increment (3 kilograms) until he can no longer achieve the required level of performance. After a man fails to reach a given level twice in succession, his score is read in 1 kilogram units as the highest number attained. In this study, right- and left-hand scores were recorded as separate variables. No interpretation is attached to any single numerical score *per se*. In the case of a single test administration as in this study, an individual dynamometer score would require interpretation only if there were a marked difference between scores obtained for the right and left hands.

PROCEDURE

The population of 120 submarine enlisted candidates represented an age range of 17-26 years. The tests were administered as one section of a large-scale investigation of the possible value for submarine selection of measures from several subject-matter fields (6). Two groups of six subjects each were tested weekly during an intensive three-day experimental period (6). Each such group was selected by separating, from a main group of approximately 40 submarine school candidates, the occupants of six chairs which had previously been secretly marked. In the course of an indoctrination lecture, these men were informed that they had been chosen to serve in a special study, were impressed with the necessity of complete cooperation during the testing period, and were promised compensatory liberty. All were given the opportunity of withdrawing from the study; two men did so and volunteer substitutes were found. With very few exceptions, the men were highly motivated since all desired submarine duty and felt that failure on any of the tests administered would disqualify them for such assignment.

Strict regulation of the lives of the subjects was maintained during the experimental period. They were quartered in a special barrack and ate at a separate mess.

Since it was impossible to avoid competition, this was put to use although never emphasized. Thus, although the tests were administered to a man individually, they were carried out in the presence of the rest of his group. Endurance times and other information were reported to the recorder with no attempt at concealment of results.

Although it has been indicated that men make higher scores when physical fitness tests are given immediately after arising (7, 8, 9), unfortunately the experimental schedule (6) did not

permit their administration under such basal conditions. Instead, they were conducted uniformly approximately four hours after a light noon meal at which no coffee was allowed. There was no strenuous exercise in the afternoon, nor was smoking permitted between the noon meal and the completion of a fitness test. Administered by two submarine medical officers, the tests were given in random order, one on each afternoon of the three experimental days. The men rested quietly for 15 minutes prior to each test while the administrators explained the procedures to be followed. The hand dynamometer test was given in the early afternoon of the first day.

STATISTICAL ANALYSIS AND RESULTS

Data on 109 of the 120 subjects were utilized for statistical analysis; records on the remaining men were incomplete. To the basic or derived measurements which the administration of the four tests made available were added age and body surface area, measured according to the Dubois modification of the Meeh formula (10). The 35 variables are listed in Table I, together with their means and standard deviations.

Comparison of Subject Performance with Other Young Male Populations

Behnke Step-up.—A direct comparison of the cardiovascular scores obtained by our subjects with those reported by NMRI (1) is not possible due to a minor inconsistency in scoring techniques. We used the method recommended in that report, namely the sum of the pulse beats 5-20″ and 105-135″ after the 20 step-ups, while scores actually reported by NMRI (1) were computed using an earlier formula:

$$\text{CVS} = \text{pulse beats 5-20}'' + 2\ (\text{pulse beats 120-135}'')$$

Since the pulse is gradually returning to normal following the step-ups, pulse counts are not a linear function; hence the scoring method of this study tended to result in higher scores (interpreted as poorer performance). The score range for our men was 53-107 with a mean of 77.4, compared with a range of 50-95 and a mean of 72.9 reported by NMRI for 280 Quantico Marines (1).

On the endurance phase of the Behnke test, subject score range was 55-300* with a mean of 199.2″, compared to the range of 29-520 and the mean of 94″ reported for the NMRI study (1).

Only one of our subjects scored below the 60″ endurance time regarded as minimal (1). His pulse rate after endurance was 140, indicating that he had not exerted himself. Inspection of the

* This was the cut-off point arbitrarily established for the test.

TABLE I

MEANS AND STANDARD DEVIATIONS OF THE VARIABLES SELECTED FOR STATISTICAL ANALYSIS

	Variable number and description	*Mean*	*S.D.*
01	Resting Pulse/Min. (B)	81.9	14.7
02	Pulse 5–20″ after Exercise (B)	32.9 (131.6)*	5.9 (23.6)
03	Pulse 105–135″ after Exercise (B)	44.5 (89.0)*	8.2 (16.4)
04	Endurance Time in Seconds (B)	199.2	77.4
05	Pulse 5–20″ after Endurance (B)	50.1 (200.5)*	10.9 (43.7)
06	Cardiovascular Score (B)	77.4	12.0
07	Resting Pulse/Min. (H)	82.6	10.9
08	Endurance Time in Seconds (H)	291.0	29.9
09	Pulse 5–20″ after Endurance (H)	47.1 (188.3)*	9.6 (38.5)
10	Pulse Increase after Endurance/Min. (H)	105.7	37.6
11	Pulse 1–1½′ after Endurance (H)	73.3 (146.6)*	14.2 (28.4)
12	Pulse 2–2½′ after Endurance (H)	64.0 (128.0)*	8.7 (17.4)
13	Pulse 3–3½′ after Endurance (H)	59.2 (118.4)*	6.3 (12.6)
14	Harvard Score (H)	75.5	13.3
15	Age in Months	227.5	18.1
16	Standing Pulse/Min. (S)	91.0	13.5
17	Points for Standing Pulse (S)	1.6	1.0
18	Reclining Pulse/Min. (S)	68.0	9.9
19	Points for Reclining Pulse (S)	2.5	0.7
20	Standing Systolic Blood Pressure in mm.Hg. (S)	112.8	10.6
21	Standing Diastolic Blood Pressure in mm.Hg. (S)	81.1	7.3
22	Reclining Systolic Blood Pressure in mm.Hg. (S)	115.7	9.4
23	Reclining Diastolic Blood Pressure in mm.Hg. (S)	70.8	7.2
24	Standing Pulse Pressure in mm.Hg. (S)	31.7	8.6
25	Reclining Pulse Pressure in mm.Hg. (S)	44.8	9.3
26	Pulse/Min. after Exercise (S)	103.8	12.7
27	Seconds for Pulse to Return to Normal (S)	31.1	23.8
28	Points for Pulse Increase (Reclining to Standing) (S)	0.8	1.5
29	Points for Blood Pressure Increase (S)	0.6	1.5
30	Points for Pulse Increase after Exercise (S)	1.5	1.1
31	Points for Pulse Return (S)	2.6	0.8
32	Schneider Score	9.5	4.1
33	Dynamometer Score in Kgs., Right Hand	46.8	6.4
34	Dynamometer Score in Kgs., Left Hand	46.4	6.6
35	Body Surface Area in Square Meters	1.8	0.1

* These additional values are given in order to present all pulse counts in comparable terms for the purpose of discussion in the body of the report. They are relative rather than actual values. Thus, in variable 02, for example, the mean in parentheses (131.6) does not imply that pulse counts were continued for one minute after the exercise; it is simply the rate 5-20″ after exercise expressed in terms of beats per minute.

original scoring sheet for this man disclosed the medical officer's notation that this individual was poorly motivated and "reluctant." Two other men had pulse rates of 140 with endurance times of 100 and 125 seconds respectively, indicating that, according to NMRI standards (1), they too could have continued longer.

The assertion of the test developers that the two phases of the Behnke test are distinct entities with little connection is borne out in the case of this data by a correlation of .055.

Harvard Step-up.—The subjects had a score range of 27-106 and a mean score of 76. This duplicates the mean obtained by 2,200 Harvard college students irrespective of training, although

the range in the latter case is considerably wider (15-154). Subject performance compared favorably with that of the 1942 Harvard freshman class (mean of 69) and the Enlisted Reserve Corps of the same year (mean of 73), but was below the average (mean score of 81) of the ROTC senior class (2).

Schneider Index.—The subjects had a range of 0-18 and a mean of 9.5 for this test. This mean is considerably lower than the 13.6 made by 200 civil airline pilots under non-basal conditions (7). However, it should be noted that our subjects had a very restricted age range (17-26 years) compared to that of the pilots (20-47 years). Inasmuch as the Schneider Index is heavily weighted to penalize a rapid pulse rate, it is interesting to note that the pilot study revealed:

> . . . a fairly constant tendency for the oldest age group (40-47) to show a significantly smaller increase in pulse rate standing and after exercise than did the younger groups (7).

For the youngest group (21-29) in the pilot study, the mean score under non-basal conditions was 10-1, bringing it closer to the mean of our subjects.

Subject mean score suffered by comparison with the mean of 14.8 attained by 134 Columbia University athletes (11). The high scores made by these men are attributed to the fact that as athletes in training they had achieved relatively stable cardiovascular systems (11). An unselected group of 191 males investigated in the same study had a mean of 12.6.

Since our subjects felt that failure to pass any test would disqualify them for submarine school, it is reasonable to assume that they were under much more emotional strain than that experienced, say, by a group of college students participating in a similar test but with nothing at stake. Not only has emotional stress been shown to have a lowering effect on Schneider scores (11, 12), but mental work even independent of emotional factors has been found to increase pulse and blood pressure rates (13). In this connection it is interesting to note that subjects in our study who took the Schneider test in the afternoon of the third experimental day (and whose early afternoon schedule included administration of the group Rorschach inkblot test) had a mean score of only 7.4, compared to the mean of 10.8 for the men who took the Schneider on the first and second experimental days. A difference of this magnitude could be due to chance factors, but the anxiety of the subjects to do well, and the various activities which preceded the fitness tests on each day's experimental schedule may well have combined to lower scores.

However, although the performance of our subjects thus suffers by comparison with scores obtained on the same tests by other

groups, the effect of the schedule on the individual tests of this study would cancel out due to the randomization of design.

Hand Dynamometer.—Scores ranged from 30-65 kilograms with a mean of 47 kilograms. The performance of 169 men reported by NMRI (5) ranged from 36-75 kilograms with a mean of 54 kilograms. Right- and left-hand scores for our subjects correlated .79, exactly reproducing the correlation reported in the NMRI study (5).

Correlation Between Fitness Tests

Correlation between the fitness tests was low. The endurance phase of the Behnke test correlated .231 with the Harvard score and .038 with the Schneider. The cardiovascular phase of the Behnke test correlated —.282* with the Harvard and —.284* with the Schneider. Harvard and Schneider final scores correlated .082. Thus, this study supports previous contentions (14, 15) that various tests which claim to measure the general trait of physical fitness correlate very poorly.

Factor Analysis

In an attempt to explain this noticeable lack of correlation, the data were further appraised by factor analysis. The particular technique employed was a Thurstone Group Centroid method (16) as modified by statisticians of the Personnel Research Section, Adjutant General's Office, Department of the Army (17).

The raw data of factor analysis are correlation coefficients, that is, statements of relationships between measurements studied two at a time. Factor analysis explains each of these correlation coefficients by means of a number of factors, or underlying bases of association, much less numerous than the original measurements. Results are presented in the form of factor loadings. A loading represents the correlation between a given measurement and one of the factors isolated, and may be positive or negative in sign depending on the nature of the relationship involved. The factor loading squared gives the percentage of score variance which may be explained or predicted by the factor in question. In this study, a loading of .20 or higher is regarded as significant.

Results of this factorial appraisal of physical fitness data will be discussed in as general terms as possible for the convenience of the non-statistical reader. If occasionally this gives rise to the impression that some of the remarks are in the nature of "ex cathedra" utterances, it is emphasized that there is a statistical

* High scores on the cardiovascular phase of the Behnke test are interpreted as poor, while high Harvard and Schneider scores are interpreted as good; hence, the negative correlation.

justification for all conclusions made. Statistical verification is presented in the table of intercorrelations (Table II), the factor loadings (Table III) and the residuals (Table II) arising when one attempts to predict the intercorrelations from the factor loadings. This material is included so that the reader may check the thoroughness of the statistical treatment if he desires to do so.

In reading the discussion which follows, the reader is reminded that the designations assigned factors are a matter of the authors' interpretative judgment rather than a problem in statistics, and that he is free to consider and suggest alternate names.

A factor, A, was found for resting pulse measures (variables 01,07,18), standing and mild exercise pulse measures (variables 16,26), and for pulse measures after recovery from strenuous exercise (variables 02,03,12,13). It was felt that this factor represented a basic physiological condition underlying pulse measurements, and accordingly it was designated *basic resting pulse.*

The taking and recording of resting pulse rate is a standard part of most physical checkups, and deviation from the expected normal rate is part of the diagnosis of certain diseases. The concept is well established, then, and the isolation of such a factor was to be expected. The surprising and somewhat disturbing point, however, is the relatively small portion of individual difference in pulse readings which can be accounted for by this basic physiological factor. Even under fairly ideal conditions (variables 01,07,18), only about 25-36 percent (squares of factor loadings) of individual variation in pulse readings can be attributed to anything having day-to-day stability, and the major part of such individual variation must be accounted for by situational, short-term, or chance factors rather than attributed to actual physiological condition. Reliance in any single measure of resting pulse, then, is small indeed.

A factor, B, was present only for the standing pulse and pulse after-exercise measures of the Schneider test. These represent moderate exercise pulse rates which are higher than the resting pulse rates for the three fitness tests, but lower than the other pulse measures taken. Hence, the factor is called *pulse response to mild exercise.* The fact that these moderate exercise pulse rates are not at all related to pulse rates taken after the exhaustive endurance runs indicates that they provide no basis for predicting the pulse response to greater loads, hence they are regarded as useless for the particular purposes of this study.

A factor, C, was found for all pulse measures taken after strenuous exercise. It appeared first in the 110-140 pulse range and persisted when the pulse returned through these levels after exercise. When the rate rose to the 150-200 level, pulse measure-

TABLE II

PHYSICAL FITNESS POPULATION, 109

Intercorrelations

	Test	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17
	01		.42	.72	.02	.26	.70	.35	.03	.05	-.05	.03	.13	.21	-.09	-.10	.35	-.29
	02	-.05		.43	-.04	.44	.79	.31	.11	.18	.09	.29	.32	.39	-.22	-.10	.22	-.22
	03	.08	-.13		.06	.21	.90	.41	-.07	.05	-.06	.17	.27	.30	-.25	-.04	.35	-.30
	04	.02	-.12	.06		.16	.02	.01	.31	-.16	-.18	-.11	-.08	-.05	.23	-.07	.03	-.06
	05	-.06	.10	-.12	.15		.36	.22	.03	.35	.27	.35	.27	.18	-.18	-.07	.11	-.15
	06	.00	.12	.06	.01	-.02		.44	.00	.13	.00	.26	.34	.40	-.28	-.08	.34	-.31
	07	.01	-.07	-.04	-.06	-.02	-.02		-.09	.19	-.09	.24	.35	.47	-.34	.02	.21	-.21
	08	-.01	-.01	-.01	.08	-.01	-.02	-.03		-.30	-.31	-.39	-.28	-.08	.73	-.23	.08	-.04
	09	-.04	.00	-.03	.00	-.02	.02	.08	.04		.96	.71	.52	.42	-.61	.06	.02	-.04
	10	-.03	-.04	-.01	-.03	-.03	-.01	-.04	-.02	.06		.67	.45	.31	-.55	.07	-.03	.02
	11	-.01	.01	.01	.02	.05	.05	.00	.01	-.06	-.07		.76	.58	-.83	.16	.00	-.02
	12	.09	-.05	.04	-.07	.03	.05	-.07	-.02	.03	.01	.01		.84	-.79	.15	.14	-.12
	13	.04	.01	.00	-.04	-.07	.06	.04	.08	.02	-.02	.00	.08		-.64	.09	.22	-.19
	14	-.02	.00	.01	.02	.00	.00	-.07	.07	.03	.03	-.04	-.07	-.09		-.26	-.06	.05
	15	.02	-.02	.04	-.02	.00	.02	.01	-.01	-.02	.00	.05	.02	.02	-.05		-.04	.05
	16	.01	-.08	-.04	-.05	-.01	-.07	-.07	.01	-.03	-.05	-.03	-.04	-.04	.02	.02		-.92
Residuals	17	.01	.03	.02	.02	-.04	.02	.01	.03	.02	.07	-.01	.00	.02	.01	.00	.03	
	18	.05	-.11	.00	-.02	-.07	-.01	-.01	.03	-.05	-.02	-.01	-.01	-.06	.02	.00	.10	-.08
	19	.05	.05	-.03	.04	.07	-.08	.05	.02	.04	.00	-.06	-.05	.07	.05	.04	.08	-.10
	20	.04	-.03	.03	-.04	.00	.09	-.04	-.01	.09	.04	-.03	.03	.04	-.04	.01	-.04	-.02
	21	.05	-.02	.03	.07	-.03	.04	.03	.04	.07	-.01	.02	-.04	-.01	.03	-.02	-.03	-.05
	22	.08	.05	.05	-.05	.03	.06	.02	-.03	.07	.05	.00	.07	.05	-.05	.03	-.05	-.03
	23	.08	.03	.00	-.05	.07	.05	-.05	.05	.03	.03	-.04	-.01	.01	.06	-.01	-.03	-.01
	24	-.04	-.01	-.01	-.04	.01	.06	-.09	.07	-.03	.01	-.10	.00	.00	.01	.02	-.04	.05
	25	.00	.00	.01	.02	-.07	-.01	.02	.00	-.04	.01	-.04	.00	-.01	-.02	.02	.06	-.11
	26	.04	-.02	.02	-.01	.03	.02	.02	.01	.00	-.07	-.01	-.03	.02	.00	-.04	-.05	.06
	27	-.05	-.02	-.03	.06	.00	-.05	.02	-.02	-.02	-.02	.01	.10	.06	-.01	-.01	-.01	.00
	28	.01	.09	.01	-.02	.08	.06	.01	.01	.07	.15	.07	.09	.07	-.04	.03	-.02	.01
	29	-.01	-.04	.06	.08	.05	.11	.02	.03	.08	-.02	-.02	.06	.01	-.03	.00	.07	-.09
	30	.05	.07	-.05	.04	.03	-.02	.06	.03	-.02	.02	.02	.00	.02	.02	.06	.14	-.14
	31	.02	.03	.02	-.01	-.01	.03	.06	.02	.00	.01	.03	.02	.04	-.03	.02	-.03	.02
	32	-.01	.02	.00	-.01	.04	.04	.02	.05	.06	.07	.01	.04	.04	-.01	.05	-.01	.03
	33	.04	-.01	.02	.06	.02	.02	-.01	.06	-.04	-.01	-.06	.04	.01	.02	.08	.03	-.02
	34	.01	-.07	.04	.14	.01	.04	.04	.03	-.03	-.02	-.04	.02	.01	-.01	.03	.05	-.05
	35	-.02	.03	-.05	-.18	-.02	.01	-.06	-.01	-.01	.01	-.06	-.05	-.02	.01	-.03	-.08	.10

ments rested almost entirely on this reaction to violent exercise, and basic resting pulse rate and diurnal-situational factors were absent or present minimally. Since the conditions (violent exercise) leading to influence by this factor are related to potentially dangerous conditions of stress, factor C is considered of consequence in the service selection picture. Current methods of scoring unfortunately give little weight to the factor.

Factor C shows up more clearly on the pulse readings of the Harvard test than it does on those of the Behnke endurance test. Possibly this is due to the greater speed with which high pulse rates are approached in the latter, and the earlier cessation of endurance caused by the greater pulse acceleration of the Behnke test. In order to include the temporal connotation, factor C is labelled *pulse response to prolonged violent exercise.*

A factor specific to the pulse measurements of each of the

TABLE II (Continued)

PHYSICAL FITNESS POPULATION, 109

Intercorrelations

	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
	.39	-.16	.09	.10	.10	.04	.03	.08	.30	.08	-.24	.02	-.17	-.10	-.24	.28	.18	.11
	.10	-.01	.15	.17	.10	.16	.04	-.02	.25	.04	-.20	.02	-.14	-.04	-.16	.09	.00	.19
	.34	-.15	.20	.22	.23	.14	.06	.12	.37	.11	-.27	-.02	-.33	-.14	-.30	.30	.22	.16
	.04	-.03	.12	.09	.00	.06	.07	-.04	.09	.02	-.06	.12	-.05	-.02	-.04	-.05	.03	-.23
	.08	-.03	.13	.04	.13	.06	.13	.08	.16	.20	-.03	.06	-.08	-.19	-.10	.20	.20	.15
	.29	-.11	.22	.23	.21	.18	.07	.08	.38	.09	-.28	.00	-.30	-.11	-.28	.25	.15	.20
	.36	-.25	.22	.24	.26	.19	.06	.12	.31	.08	-.13	-.02	-.16	-.04	-.19	.14	.20	.11
	-.05	.06	-.17	-.06	-.14	.02	-.16	-.15	.01	-.26	-.11	-.04	.03	.29	.01	-.12	-.18	-.18
	.07	-.11	.24	.09	.20	-.05	.22	.23	.06	.19	.00	.08	-.06	-.14	-.04	.07	.15	.20
	-.03	-.04	.18	.02	.12	-.12	.21	.22	-.02	.18	.03	.08	-.01	-.14	.01	.02	.08	.18
	.01	-.04	.25	.22	.20	.05	.12	.17	.06	.10	-.02	.03	-.03	-.07	-.02	.14	.22	.27
	.11	-.06	.28	.18	.28	.11	.19	.20	.22	.12	-.12	.00	-.16	-.09	-.13	.14	.18	.19
	.16	-.09	.20	.17	.20	.09	.10	.13	.30	.06	-.20	-.02	-.17	-.01	-.18	.12	.17	.18
	-.09	.06	-.29	-.21	-.26	-.07	-.18	-.21	-.15	-.20	.04	-.03	.11	.18	.08	-.17	-.24	-.28
	.02	.01	.04	.00	.02	.04	.05	-.01	-.05	.02	.10	.00	.09	-.02	.08	-.06	-.08	-.10
	.74	-.58	-.05	-.04	.14	.04	-.03	.11	.81	.00	-.89	-.24	-.53	-.09	-.87	.12	.03	.06
Residuals	-.71	.58	.00	.00	-.15	-.05	.00	-.11	-.76	-.04	.84	.16	.50	.12	.85	-.10	-.03	-.02
		-.82	.11	-.01	.25	.02	.15	.11	.66	.04	-.48	-.13	-.43	-.10	-.65	.00	-.03	-.06
	-.09		-.11	.09	-.15	-.20	-.21	.00	-.52	-.05	.40	.05	.34	.10	.58	.02	.05	.04
	-.07	-.02		.59	.64	.28	.73	.44	.13	.22	.13	.46	-.18	-.18	.12	.11	.08	.28
	-.10	.10	.13		.34	.25	-.12	.15	.10	.13	.04	.24	-.12	-.08	.08	.04	.07	.24
	.02	-.06	.00	-.03		.40	.50	.70	.31	.14	-.01	-.29	-.26	-.12	-.25	.19	.12	.26
	-.06	-.09	-.08	.00	.17		.13	-.37	.12	-.04	.05	-.14	-.01	.06	-.08	.02	-.02	.04
	-.08	-.09	.01	-.14	.11	.11		.41	.08	.16	.12	.36	-.11	-.15	.08	.09	.03	.14
	-.06	-.06	.10	-.03	-.01	-.08	-.03		.22	.18	-.05	-.19	-.25	-.16	-.20	.18	.14	.23
	.06	.07	.00	.00	.01	.02	-.03	.07		.23	-.68	-.24	-.76	-.23	-.84	.08	-.05	.11
	-.06	.03	.08	-.08	-.01	.02	.11	-.02	.00		.06	.07	-.21	-.93	-.22	.17	.16	.11
	-.06	-.06	-.02	.01	.02	.02	-.03	-.10	.05	.05		.21	.47	.02	.83	-.14	-.08	-.06
	-.05	.04	.04	-.06	-.15	-.04	.07	-.09	.00	-.03	-.03		.08	-.07	.50	-.02	.05	.08
	.04	-.11	.00	-.01	.02	.06	.04	-.09	-.11	.00	-.09	-.06		.23	.63	-.14	.00	-.13
	.04	.02	.01	.03	.00	.03	.06	.02	.06	-.03	.01	-.02	-.03		.29	-.16	-.15	-.08
	-.12	.03	-.06	.00	-.03	-.05	-.06	-.08	-.03	.07	.07	-.04	.02	-.04		-.14	-.03	-.04
	.02	-.04	.05	.00	.05	.08	-.01	-.03	.05	.03	-.04	.01	-.04	-.01	-.03		.79	.58
	.00	.03	-.01	.02	.02	.05	-.09	-.04	.00	.02	-.08	-.03	.02	.00	-.03	.01		.56
	-.09	.05	.04	.09	.04	-.09	-.01	.10	.00	.02	.08	.07	.01	.02	.07	.02	.03	

three fitness tests was isolated. Thus, measurements taken for the three tests exhibited some influence peculiar to each, one which was not carried over from one situation to another. These factors are taken to indicate that pulse-rate differences among individuals tend to remain relatively constant for any given day, but that such differences are not repeatable from day to day. The factors are designated *diurnal stability specifics*—Behnke (D), Harvard (E), and Schneider (F).

Interpreted thus, the factors throw some light on the low reliability of pulse measurements from one day to another noted in connection with factor A, and help to explain the frequently observed fact that an applicant failing to meet pulse rate standards on a given examination under a given examiner, may qualify upon subsequent examination by either the same or a different examiner.

These diurnal pulse stability factors indicate also that service

TABLE III

FINAL FACTOR LOADINGS

Variable number and description		Pulse factors					
		A	B	C	D	E	F
01	Resting Pulse/Min. (N)	.50	-.02	.03	.56	-.10	.15
02	Pulse 5–20" after Exercise (N)	.51	.12	.30	.42	.10	-.08
03	Pulse 105–135" after Exercise (N)	.60	.12	.02	.59	.03	.04
04	Endurance Time in Seconds (N)	.09	.05	-.03	-.04	.06	.00
05	Pulse 5–20" after Endurance (N)	.25	-.09	.40	.26	.00	.08
06	Cardiovascular Score (N)	.64	.19	.12	.69	.01	-.05
07	Resting Pulse (H)	.60	-.13	.07	.10	.24	.11
08	Endurance Time in Seconds (H)	-.04	.04	.04	.08	-.05	-.01
09	Post Exercise Pulse/Min. (H)	.01	-.10	.81	.03	-.04	.19
10	Pulse Increase after Exercise (H)	-.14	.06	.84	-.01	-.06	.10
11	Pulse 1–1½' after Exercise (H)	.16	.03	.70	-.03	.22	-.09
12	Pulse 2–2½' after Exercise (H)	.46	.13	.52	-.19	.53	-.19
13	Pulse 3–3½' after Exercise (H)	.50	.05	.42	-.08	.41	-.03
14	Harvard Score (H)	-.26	-.09	-.40	.00	-.23	.09
15	Age in Months	.01	-.04	-.02	-.13	.08	-.02
16	Standing Pulse (S)	.49	.61	.03	.02	-.02	.60
17	Points for Standing Pulse (S)	-.43	-.57	-.03	.02	.05	-.62
18	Reclining Pulse (S)	.51	.07	-.03	.02	.00	.61
19	Points for Reclining Pulse (S)	-.40	.07	.00	.19	.05	-.84
20	Standing Systolic Blood Pressure (S)	.14	-.01	.16	.06	.13	-.01
21	Standing Diastolic Blood Pressure (S)	.17	-.02	.10	.09	.13	-.08
22	Reclining Systolic Blood Pressure (S)	.11	.12	.11	-.04	.09	.21
23	Reclining Diastolic Blood Pressure (S)	.12	.03	-.04	.04	.08	.00
24	Standing Pulse Pressure (S)	.10	-.01	.10	-.03	.08	.07
25	Reclining Pulse Pressure (S)	.07	.02	.16	-.05	.04	.11
26	Pulse/Min. after Exercise (S)	.48	.55	.04	-.05	.07	.51
27	Seconds for Pulse Return to Normal (S)	.12	-.02	.09	.04	-.06	.10
28	Points for Pulse Increase R to S (S)	-.36	-.66	-.15	.01	.00	-.41
29	Points for Blood Pressure Increase (S)	-.03	-.30	.06	.08	.03	-.17
30	Points for Pulse Inc. after Exercise (S)	-.36	-.44	-.03	.02	-.03	-.40
31	Points for Pulse Return (S)	-.17	-.07	-.02	.00	-.07	-.07
32	Schneider Score (S)	-.38	-.55	-.06	.08	.00	-.58
33	Hand Dynamometer Score, Right	.11	.05	.02	.11	.01	.01
34	Hand Dynamometer Score, Left	.10	-.12	.09	.01	.07	.01
35	Body Surface Area	.11	.12	.18	.04	.05	.02

personnel who qualified a month (or even a day) previously, may not necessarily qualify for flight or other exacting duty on any given day. Since they suggest that a particularly high or low pulse reading will tend to persist for the next several hours at least, they lend support to the practice of taking pulse measurements immediately before potentially physically exhaustive assignments.

An average pulse reading with a reliability of .90 may be obtained for an individual's basic pulse rate *on any given day* by taking three measures of resting pulse. This correlation is based upon the correlation of .72 between variables 01 and 03 in the Behnke test.*

Reliability for readings on the same day should not be taken

* Spearman-Brown Prophecy formula (18).

TABLE III (Continued)

FINAL FACTOR LOADINGS

Endurance factors				*Blood pressure factors*					
G	H	I	J	K	L	M	N	O	h^2
.01	.12	.04	.01	−.13	.01	.05	.05	.03	.64
.08	.03	−.01	.10	.04	.00	−.01	−.08	.04	.58
−.09	.13	.04	−.03	.06	.00	−.01	.04	−.09	.77
.30	−.05	.04	.11	.11	.09	.11	−.09	.02	.16
.00	.12	.15	.09	−.04	.04	.04	.02	−.06	.36
−.04	.06	.04	.00	.04	−.05	−.04	.05	−.11	.97
−.04	.09	−.02	.04	.17	.05	.00	−.04	−.13	.52
.78	.00	−.03	.31	−.06	−.10	−.08	.00	−.01	.74
−.45	−.03	−.01	−.02	−.08	.10	.09	.03	−.11	.95
−.42	−.08	.03	.03	−.09	.06	.09	.03	.08	.95
−.51	.09	−.09	.00	.09	.06	.02	−.02	−.06	.87
−.29	.00	−.08	.01	.05	.03	.00	.02	−.11	.96
−.19	.03	−.12	.03	.00	−.03	−.04	.02	−.04	.66
.76	.01	.06	.20	−.13	−.03	.01	.01	.06	.94
−.22	−.20	−.03	−.08	.05	.01	.00	−.04	−.01	.13
.06	.03	−.09	.03	−.04	−.05	−.04	−.03	.00	.99
−.06	−.02	.05	−.03	.09	.01	.00	.09	−.05	.92
−.02	−.10	−.04	−.06	.04	.18	.03	.04	.02	.69
−.01	.07	.07	.00	−.02	−.07	.00	.19	−.14	.98
−.05	.10	.04	.01	.69	.46	.41	.04	.19	.97
−.08	.07	.06	−.01	.54	.22	−.38	.15	.30	.68
−.04	.16	.08	−.02	.70	.05	.21	.52	−.19	.97
.01	−.01	−.06	.00	.60	.04	−.08	−.44	−.23	.64
−.11	.06	.01	−.02	.15	.61	.69	.10	.02	.93
−.12	.15	.14	−.01	.11	.25	.19	.87	−.15	.99
.01	−.06	.14	.02	.08	.01	.00	.02	.03	.83
−.24	−.03	.89	−.07	.08	.00	−.04	.05	.18	.94
−.07	−.06	.09	−.06	.15	.19	.11	.05	−.12	.86
−.02	.05	−.04	.00	.10	.24	.17	−.08	.80	.88
−.03	−.04	−.14	−.01	−.09	−.07	−.04	−.03	−.06	.53
.24	.04	−.90	.08	.00	−.13	−.10	.04	−.08	.95
−.01	.01	−.27	−.01	.08	.20	.13	−.03	.21	.97
−.21	.86	.12	−.08	−.10	.01	.03	.03	−.07	.85
−.23	.81	.11	−.06	−.10	.00	.05	−.01	.00	.77
−.20	.58	.03	−.03	.13	.06	.02	−.08	−.04	.47

to warrant predictions concerning the next or any other day, for there the reliability drops to the neighborhood of .35, and emphasizes the essentially diurnal nature of the stability.

A factor, G, appeared on the endurance time in second variables of the two tests which measured endurance, and accordingly was labelled *endurance under violent exercise.* It showed more clearly for the Harvard than for the Behnke test. These two tests differ primarily with respect to the *rate* at which the exhaustion level is reached. The longer (mean of 291.0 versus 199.2 seconds) and more uniform time (standard deviation of 29.9 versus 77.4) of the Harvard test may have led to a more rigid test of endurance, or it could well be that long heavy loads and short heavier loads measure different kinds of endurance. The presence of more Harvard measures in the battery may weight the factor in the

direction of the long heavy load effects rather than short heavier load effects. In any event, endurance time in seconds appears to be a basic repeatable measure of individual differences. The question of which endurance measure is more important for the services would depend on the particular service task for which one wished to predict performance.

This endurance factor exhibited a negative relationship to pulse measures after violent exercise, indicating that failure to continue an endurance run is based in part upon cardiovascular increase, that is to say, individuals with the most pulse change tend to stop sooner. Similarly, the negative relationship between the factor and the time for pulse to return to normal indicates that persons whose increased pulse rates take longer to return to normal after exercise also tend to stop sooner. The present data do not permit us to state whether individuals are aware of these physiological conditions and respond to them directly, or whether previous experience has conditioned them to unconscious avoidance of overexertion. In either case, assuming that motivation is adequate, cessation of an endurance run appears to be a protective device adopted sooner by persons whose physiological condition makes protection most important.

The endurance factor exhibits a negative relationship also with the strength of grip and body-surface area measures. This finding is in line with the usual negative relationship between size and weight with calisthenics such as chins and dips. Correction for weight is desirable, then, if any extrapolation is to be made to activities not involving actual lifting of the body.

The remaining negative relationship exhibited by this factor is for age, indicating that older men find such activity harder to maintain. When it is recalled that the men in this study did not exceed 26 years of age, the wisdom of establishing upper age ceilings for any armed service task requiring long maintenance of violent bodily activity is evident. Similarly, maximum weight and size ceilings should be set for tasks requiring long, continuous climbing or other sustained exertion which involves the lifting of one's own weight.

Factor H is poorly defined; hence the name assigned to it remains tentative. It is present for the hand dynamometer scores and the body-surface area measurement, and exhibits a negative relationship for age. The dynamometer loadings could indicate strength, arm muscle development, or mobilization of energy. The loading on body-surface area might indicate mere size (reflected in increased strength) or greater muscular development (only indirectly influencing size). The negative loading for age suggests that strength rather than size is uppermost. The factor

is designated *size-strength(?)*, and is considered worthy of additional study.

Other studies relating strength-size variables to endurance indicate that it is the "lifting" of the body weight required in the step-up type of test which occasions the negative relationship of these variables to endurance (19).

Factors I and J are specific factors (triplet and couplet respectively) based upon plural representation of certain scores in the matrix of correlations; hence they have no theoretical or practical importance.

A factor, K, was present on the four basic blood pressure measures, systolic and diastolic, for standing and sitting conditions (variables 20, 21, 22 and 23), and accordingly it was designated *basic height of blood pressure.* The factor is considered a basic physiological characteristic upon which meaningful classification of individuals may be based. However, the utilization of basic resting, blood-pressure measures for screening under present measurement techniques entails the same dangers as does the use of basic resting pulse discussed previously.

A factor, L, was present for all derived blood pressure measurements whether obtained (a) by taking differences between systolic and diastolic under the same conditions (called pulse pressure), or (b) by taking differences between standing and sitting levels for the same type of measurement (called blood pressure increase). The factor was designated *variability in blood pressure level.*

Blood pressure recorded when standing, then, has two components: (1) the basic level component, reflected in loadings on factor K, and (2) the variation in level due to standing, reflected in loadings on this factor L.

Factor L is considered to represent a basic physiological differential because it is present (a) on all methods of computing change, and (b) on both measures containing a variation component. The best measure is pulse pressure standing which involves both types of change.

Factors M, N and O merely confirm that the variables involved were computed according to the usual formulas. Factor M has significant positive loadings on variables 20 and 24 and a negative loading for variable 21. Thus, the factor indicates that pulse pressure standing = systolic blood pressure standing — diastolic blood pressure standing, or, variable 24 = variable 20 — variable 21.

Similarly, the loadings for factor N indicate merely that pulse pressure reclining = systolic blood pressure reclining — diastolic blood pressure reclining, or, variable 25 = variable 22 — variable 23.

Again, the loadings for factor O indicate that blood pressure

increase from reclining to standing = diastolic blood pressure standing — diastolic blood pressure reclining, *or* systolic blood pressure standing — systolic blood pressure reclining, *or* the combined form, blood pressure increase = the systolic and diastolic standing measures — the systolic and diastolic reclining measures.

Thus, factors M, N, and O are regarded as spurious in the sense of arising from plural reporting.

Influence of Physiological Components on Test Scores

This factorial appraisal of physical fitness data has revealed that the tests investigated vary in the functions which they measure and also in the importance given these functions in final test scores. What, then, does the difference in scores made by two individuals on the same test actually mean? This may be determined by squaring the factor loadings reported in Table III.

In the case of the cardiovascular phase of the Behnke test, 41.0 percent of the difference in scores of two individuals is explained by basic resting pulse, and 3.6 percent by the pulse response to mild exercise. At least half the difference in individual scores made on this test is attributable to diurnal, situational, or chance factors (e.g., the mental set of a man on the day of a test) rather than to physiological constitution.

It may be said that 6.8 percent of the difference in scores obtained by any two individuals on the Harvard test is predictable by these persons' basic pulse rates, 16.0 percent by their pulse reactions to violent exercise, and 57.8 percent by their ability to carry on exhaustive endurance runs. Only 16.8 percent of the difference in their scores is attributable to non-repeatable specific factors.

In the case of the Schneider Index, differences in the scores of individuals are explained in part by pulse reaction to mild exercise (30.2 percent) and by basic resting pulse (14.4 percent). Only 4.6 percent of score variance is predictable by blood pressure variables despite the taking of many such measures. Here, as in the Behnke cardiovascular test, half the score variance must be attributable to situational or non-repeatable chance elements, or to error.

Since there is no score for the endurance phase of the Behnke test other than time in seconds, it is not possible to speak of its "score" in terms comparable to the other scores.

DISCUSSION

This paper does not attempt to delineate the physiological functions which should be included in an estimate of the general trait of physical fitness. That is the province of specialists in this area. There is no implication intended, then, that the functions

isolated by this study are the only components of value in gauging physical fitness. Rather they are the only physiological functions actually measured by the tests investigated.

When agreement has been reached on just what components should be represented in a fitness appraisal and how relatively important each component is in such an estimate, test scores may then be devised to incorporate these factors in the appropriate percentages.

The present study offers a lead for such a re-evaluation and systematization of fitness estimates, for it has shown that the influence of physiological functions on the tests investigated is a reflection of the scoring method of each test. It has indicated, for instance, that a certain pulse reaction to prolonged violent exercise is characteristic of the individual, but that the Schneider battery contains no estimate of this function, and that while it is measured by both the Behnke and Harvard tests, their current scoring methods show little influence from it. Inasmuch as it is the pulse rate in recovery rather than endurance time *per se* which is considered to set aside superior men from men merely good (20), it is regrettable that more weight is not given to this factor.

Basic height of blood pressure and variability in blood pressure levels are components which also can form the bases for meaningful classification of individuals, but the Behnke and Harvard tests exclude these measures, and the Schneider, after taking several measures of these promising components, virtually ignores their influence in its final score.

CONCLUSIONS

1. There is a basic resting pulse rate which characterizes each individual and which tends to remain relatively constant during any given day. However, day-to-day stability is low; hence reliability for readings taken on the same day do not warrant predictions concerning readings for the next or any other day.

2. Pulse response to prolonged violent exercise is a basic physiological factor upon which meaningful classification of individuals may be based.

3. Endurance time in seconds is a basic repeatable measure of individual differences. Items which contribute to the lowering of endurance scores for a given individual are (1) high increase in pulse following violent exercise, (2) slow return of pulse to normal after exercise, (3) high standing in size-strength variables, and (4) increasing age.

4. There is a basic resting blood pressure rate which characterizes each individual and influences his pulse reactions to exercise.

5. Variability in blood pressure level due to slight changes in environmental conditions is characteristic of the individual. Its best measure is pulse pressure standing.

6. The fitness tests investigated varied widely in the choice of physiological functions which they actually measured, and also in the contribution of these items to final test scores. The final score of the Harvard test is much less contaminated by non-repeatable situational and chance factors than are the scores of the other tests studied.

7. If some general measure of physical fitness is considered desirable for screening purposes, then specialists in the fitness field must first establish a hierarchy of functions essential in such an estimate. Following that, more logically weighted final scores can be devised for fitness tests.

8. On the basis of this study the following specific recommendations are made:

a. That if a measure of basic resting pulse is to be employed in estimating an individual's fitness for a special task, such pulse measurements be taken on the day of assignment itself.

b. That upper age ceilings be established for any armed service tasks requiring long maintenance of violent bodily activity.

c. That maximum size and weight ceilings be set for tasks requiring long, continuous climbing or other sustained exertion which involves the lifting of one's own weight.

d. That there be additional pulse counts taken in the endurance phase of the Behnke test as the exercise pulse returns to normal, and that a formula combining endurance time with the pulse changes resulting from endurance be employed for scoring.

e. That the Harvard scoring formula be slightly revised to give more weight to pulse increase with prolonged violent exercise, and less weight to endurance time.

f. That the Schneider scoring formula be revised to include contribution of blood pressure factors which are virtually ignored under the present scoring procedures.

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An Annotated Bibliography on Gymnastics and Tumbling

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INTRODUCTION

SINCE the conclusion of World War II, there have been numerous indications that gymnastics was re-emerging into a place of prominence in physical education classes and in athletic competition. More institutions are sponsoring varsity gymnastic squads, there has been increased competition in Amateur Athletic Union meets, and the popular trampoline has given a new impact to the sport.

Consequently, it seems worthwhile to have an annotated bibliography to which responsible teachers can turn for information. The Library of Congress, the library of the Department of the Interior, and the Inter-Library Loan service have been used in compiling the present list of references. Though unintentional, unquestionably some published and unpublished material has been overlooked. It would be appreciated if any such references can be forwarded to the writer.

Though hand-balancing, vaulting, pyramids, and other exhibitional activities are related to the present research, these references are not specifically referred to except as they come under a more general category.

For best results, cross-checking is suggested. For instance, if the reader were interested in an article pertaining to the horizontal bar, his search would be incomplete until he checked the references both under the heading of "Horizontal Bar" as well as those under "General Apparatus and Tumbling."

COMPETITION

Periodicals

1. "Gymnastic Point Contest, Minneapolis YMCA," *Physical Training,* 21:6:220 (April, 1924). Clever methods for stimulating interest in gymnastics by awarding points for stunts on the various pieces of apparatus.*
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3. ————, "Gymnastics for You," *The Body Builder,* 3:6:18 (June, 1948). Relates the progress of the Japanese gymnasts since the last war, and also discusses the Central AAU Gymnastic Championships.

* Readings so marked are of particularly high caliber.

4. ———, "Champion Performers," *The Body Builder,* 4:6:17 (June, 1949). A résumé of the 1949 NCAA, Western Conference, and Central AAU gymnastic meets.

5. Di Giovanna, Vincent, "A New Approach to an Old Problem," *J. of Health and Physical Education,* 7:7:400 (September, 1941). Excellent suggestions for the administration of gymnastic classes.*

6. *Gymnastic Handbook* (published annually by Amateur Athletic Union). Lists the results of gymnastic competition throughout the United States during the preceding year as well as describing required routines for national competition.*

7. Keeney, Charles J., "Spectator Aid for Gymnastic Meets," *J. of Health and Physical Education,* 9:10:618 (December, 1938). Explains the importance of considering the spectator if competitive gymnastics is ever to be vitalized. Excellent suggestions for limiting competition, pre-meet planning, and photographs of scoreboards.*

8. Luther, Ruth M., "An Elementary School Tumbling Meet," *School Activities,* 8:6:260 (February, 1937). Much interest was found in tumbling in fifth and sixth grades. A total of 240 boys and girls participated, and the meet was preceded by six weeks of practice. The seven events included three forward rolls, three rolls with hands on ankles, three rolls using no hands, dive over mat and roll, dive over two people, headstand, and cartwheel.

9. Mendizabel, A. B., "Training for Gymnastic Competition," *School* (*Sec. Ed.*), 25:3:235 (November, 1936). Helpful pointers in the training of a high school gymnastic team.*

10. Miller, Charles E., "Nebraska's First Gym Championship," *Scholastic Coach,* 9:10:14 (June, 1940). Good ideas on the administration of a state gymnastic championship.

11. Price, Hartley O., "Do You Want To Be a Successful Gymnast?" *Athletic Journal,* 20:5:20 (January, 1940). Lists the values of gymnastics, and offers suggestions for stimulating interest of boys with stunt charts, standards of achievement, clubs, photographs, and the cooperation of each student interested in the sport.*

12. ———, "Versatility in Gymnastics," *Athletic Journal,* 21:5:20 (January, 1941). Stresses versatility rather than specialization for a young high school gymnast.*

13. ———, "A Proposal for Competitive Developmental Gymnastics in the YMCA Program," *J. of Physical Education,* 40:3:46 (January-February, 1943). Tells how the YMCA might contribute more to the field of gymnastics. Similar to the article in December, 1942, issue of the *Athletic Journal.*

14. ———, "Motivation Devices for the Gym Program," *Scholastic Coach,* 14:4:14 (December, 1944). States that an activity is neither formal nor informal, this being determined by the method of instruction. Shows how the success of the program depends upon the creation of an atmosphere that will motivate the individual to become a proficient gymnast.*

14*a*. Romeo, Paul C., "Speedline Method for Scoring Competitive Gymnastics," *Athletic Journal,* 30:5:28 (January, 1950). Excellent description of the latest method of judging a gymnastic meet. Each of three judges has own telephone to call scores to the scoring table.*

14*b*. Welser, Lyle, "Gymnasts Organize Southern Gymnastic League," *The Southern Coach and Athlete,* 11:20:24 (June, 1949). Explains the

* Entries marked with a letter were added after the original manuscript was completed.

formation of the Southern Gymnastic Conference. Much credit given to Mr. William Alexander of Georgia Tech.

15. Wettstone, Eugene, "Tests for Predicting Potential Ability in Gymnastics and Tumbling," *Research Quarterly,* 9:4:115 (December, 1938). An abstract of the author's master's thesis. Discusses a test used primarily as a finding device for potential varsity gymnasts. Correlates .79 with predicting gymnastic ability.
16. ———, "Some Helpful Hints in the Organization of a Gymnastic Team," *The Physical Educator,* 1:3:130 (February, 1941). Lists equipment companies and periodicals that would prove helpful to a coach of gymnastics. Suggests bulletin boards and motivational charts.*
17. Wey, Herbert, "Varsity Gymnastic Team of Appalachin, North Carolina, High School," *School Activities,* 19:4:135 (December, 1947). Tells how gymnastics was promoted to the rank of a varsity sport through its exhibitions. Parallel bars were loaned by a nearby state teachers' college, and the trampoline was purchased from receipts of games.*
18. White, A. Dalton, "Gym Meet," *School* (*Sec. Ed.*), 33:8:698 (April, 1945). Elementary instruction for the formulation of a gymnastic team, and suggestions for judges.
19. Younger, M. W., "Gymnastic Coaching in the Colleges," *Athletic Journal,* 20:1:34 (September, 1939). Explains that it takes from six to eight years to develop a good gymnast, and that high school gymnastics is nurtured only when a practical man develops and stimulates the boys' natural desire to do stunts.
20. Zwarg, Leopold F., "Judging and Evaluation of Competitive Apparatus Or Gymnastic Exercises," *J. of Health and Physical Education,* 6:1:23 (January, 1935). Offers worthy suggestions for the judging of a gymnastic meet, and the evaluation of routines.*

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26. Scannell, John A. *A Manual of Heavy Apparatus and Tumbling Stunts.* Minneapolis: Burgess Publishing Company, 1948, pp. 46. Line drawings and brief descriptions of basic stunts on all the apparatus.
27. Skarstrom, William. *Gymnastic Teaching.* Washington: American Physi-

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42. Loken, Newton C., "Let's Pep Up Our Gymnastic Exhibitions," *Athletic Journal,* 28:3:24 (November, 1947). Excellent comedy stunts to be done with tiger leaping, trampoline, and tumbling.*

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49. Smith, Willard, "Gymnastics," *Scholastic Coach,* 16:6:10 (February, 1947). Describes fundamental stunts on the apparatus.

50. Stevens, Lynn R., "Is Gymnastics Losing or Gaining Ground?" *J. of Physical Education,* 25:9:174 (May, 1928). Shows the importance of having an all-round YMCA athletic program rather than one based solely on gymnastics.

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63. Rice, Emmett A., "The American Turners," *J. of Health and Physical Education,* 5:4:3 (April, 1934). Discusses the beliefs and activities of the American Turners during their early years in this country.
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THESES

72. Cobb, Frances T. *Origin and Development of the Turnverein.* Master's thesis, George Peabody College for Teachers, 1936, pp. 80. A historical sketch of the development of the Turnverein throughout the world. Special emphasis on Jahn's part in starting the movement, and also the work of Beck, Follen, and Lieber in transmitting the sport to the United States.
73. Duke, Julia L. *History of German Gymnastics.* Master's thesis, George Peabody College for Teachers, 1936, pp. 86. History of German gymnastic leaders before and after 1918 with special reference to Jahn, Mensendieck, Kallmayer, Delsarte, Muller, and Medau.
74. Perry, Gertrude V. *History and Development of the Sokol Movement of Czechoslovakia.* Master's thesis, George Peabody College for Teachers, 1936, pp. 44. Cites the contributions of Dr. Miroslar Tyrs, the founder of the Sokol movement. Shows that it started in a manner similar to that of the Turnverein; as a patriotic gesture to encourage the nation to be strong in order that it might be free. Tried to encourage national unity through group activities, and to check individualism.*
75. Schnepel, E. Paul. *The Life and Work of Friederich Ludwig Jahn.* Master's thesis, Ohio State University, 1935, pp. 122. Quite a complete biography of Jahn, and the struggle he had nurturing the Turnverein. Explains his philosophy and motives behind his interest in gymnastics.*
76. Zwarg, Leopold F. *A Study of the History, Uses, and Values of Apparatus in Physical Education.* Doctoral dissertation, Temple University, 1931. The essential points have been abstracted in Numbers 67-71 inclusive.*

HORIZONTAL BAR

BOOKS

77. Butterworth, Horace. *The Horizontal Bar.* Chicago: Horace Butterworth, 1902, pp. 192. One of the early American books on horizontal bar work. Describes routines and gives several drawings.

PERIODICALS

78. McCulloch, J. H., "Natural Activities on Apparatus," *J. of Health and Physical Education,"* 1:2:36 (February, 1930). Diagrams and instructions for elementary horizontal bar exercises.
79. ————, "Natural Activities on Apparatus," *J. of Health and Physical*

Education, 1:4:34 (April, 1930). Intermediate exercises described for the low horizontal bar.

80. ————, "Natural Activities on Apparatus," *J. of Health and Physical Education,* 1:1:40 (January, 1930). Helpful pointers in caring for the hands. Diagrams of low horizontal bar vaults.*

81. ————, "Natural Activities on Apparatus," *J. of Health and Physical Education,* 1:6:34 (June, 1930). Low and high horizontal bar movements discussed.

82. Miller, Jack, "High Bar Stunts," *Scholastic Coach,* 19:6:12 (February, 1950). Several photographs. Good descriptions for such fundamental stunts as knee and hip circles.

83. Price, Hartley O., "The Low Horizontal Bar," *Athletic Journal,* 20:7:22 (March, 1940). Good pictures and descriptions of stunts to be learned on the low horizontal bar.*

84. ————, "High Horizontal Bar," *Athletic Journal,* 20:8:19 (April, 1940). Stresses good form on the bar. Explains difficult mounts, dismounts, and various forms of giant swings.

THESES AND PROJECTS

85. Balen, John M. *A Study of the Progression of Movements on the Horizontal Bar.* Master's project, University of Southern California, 1948. Not reviewed.

86. Harris, Ralph C. *A Cinematographical Study of the Upstart on the High Horizontal Bar.* Master's thesis, Springfield College, 1939, pp. 128. Photographic evidence backed by basic physics principles for the correct method of executing the upstart (kip) on the high horizontal bar. Best performers show a swing of 50 degrees both forward and backward, body arched at end of forward swing, toes brought to the bar, a hesitation until the arms come directly under the bar, and then the important leg thrust is made. Pictures show how both the successful and unsuccessful attempts are made, and the differences are pointed out.*

87. Shay, Clayton. *Part Versus Whole Methods of Learning in Gymnastics.* Master's thesis, Syracuse University, 1934. Found that in learning the kip on the horizontal bar it took 38.5 trials average using the whole method as compared with 48.8 trials using the part method. Sixteen inexperienced college men were used as subjects. The Physical Fitness Index correlated .82 with the number of trials; Strength Index, .78; and the Brace Motor Ability test, .52.*

PARALLEL BARS

BOOKS

88. Cromie, William J. *Parallel and Horizontal Bar Exercises.* New York: American Sports Publishing Company, 1916, pp. 147. Well illustrated for work on both high and low parallel bars and the horizontal bar.

PERIODICALS

89. Price, Hartley O., "Elementary and Intermediate Parallel Bars," *Athletic Journal,* 22:5:11 (January, 1942). Advises a series of progressive stunts at first until the gymnast reaches a certain stage which will allow him to proceed with stunts he is most interested in. Suggests routines for intermediate work.*

90. ————, "Advanced Parallel Bars," *Athletic Journal,* 22:6:6 (February, 1942). Classifies advanced stunts according to (1) mounts, (2) dismounts, (3) somersaults above the bar, (4) somersaults below the bar,

(5) balances, (6) changes of direction. Excellent pictures and accompanying descriptions.*

PROJECT

91. Noble, Frank P. *A Tentative Manual for Parallel Bar Performers.* Master's project, University of Southern California, 1948. Not reviewed.

ROPE CLIMBING

PERIODICALS

92. Kogel, Carl W., "Our Aid—The Ropes," *J. of Health and Physical Education,* 11:9:551 (November, 1940). Offers suggestions for interesting stunts in rope climbing showing various ways in which the rope may be climbed.*
93. Reuter, H. C., "Climbing Exercises on Apparatus," *J. of Health and Physical Education,* 6:8:36 (October, 1935). Pictures of challenging stunts on the ropes, ladders, climbing poles.*
94. Wettstone, Eugene, "Give Them Enough Rope," *Scholastic Coach,* 14:3:9 (November, 1944). Advises rope climbing as a means of physical conditioning. Discusses the proper techniques for climbing, and shows numerous pictures of novel stunts to be done with the ropes.*

SIDE HORSE AND FLYING RINGS

BOOKS

95. Cromie, William. *Exercises on the Side Horse and Flying Rings.* New York: American Sports Publishing Company, 1921, pp. 95. Illustrated stunts on both the side horse and rings.

TRAMPOLINE

BOOKS

96. Griswold, Larry. *Trampoline Tumbling.* St. Louis: Fred Medart Manufacturing Company, 1948, pp. 120. Excellent drawings showing the physics of trampoline movements, and descriptions of numerous stunts and routines. Suggestions for grading difficulty.*
97. Loken, Newton C. *Trampolining.* Ann Arbor, Michigan: The Overbeck Company, 1948, pp. 26. Brief description, using stick figures, of all fundamental trampoline stunts in addition to more advanced ones.

PERIODICALS

98. "Concordia College Boys Try Some New Exercises on a Circus Trampoline," *Life,* 10:26:35 (June 30, 1941). Pictures of college students doing elementary trampoline stunts.
99. "Trampoline; Navy Uses Old Circus Gadget To Give Flyers Space Orientation," *Life,* 18:15:121 (April 9, 1945). Stroboscopic pictures of a Navy expert twisting on the trampoline.
100. Hatton, Charles S., "A New Use for an old Device; The Trampoline for Sport," *J. of Health and Physical Education,* 13:4:252 (April, 1942). Shows a home-made trampoline, and briefly explains how one can be made. Fundamental stunts are described.*
101. Leake, Ralph, "The Trampoline And Its Uses," *J. of Physical Education,* 29:5:97 (May-June, 1942). Tells of the popularity of this apparatus in the Omaha YMCA, and gives verbal explanations of both elementary and advanced stunts.
102. Loken, Newton C., "Trampoline Stunts," *Scholastic Coach,* 16:5:24 (January, 1947). Pictures and descriptions of beginning stunts.

102a. ————, "Advanced Trampolining," *Athletic Journal,* 29:4:37 (December, 1948). Excellent for advanced stunts and their spotting. Such stunts as double front and back somersaults, fliffi, and twisting somersaults are described.*

102b. ————, "The Advancement of Trampolining," *Athletic Journal,* 30:4:28 (December, 1949). Tells of the numerous advanced trampoline stunts now being performed by collegiate gymnasts. Cites the dangers of such work, and explains methods by which coaches are trying to emphasize form and continuity rather than difficulty.

102c. Miller, Charles E., "Organizations for Trampolining," *Scholastic Coach* 19:1:30 (January, 1950). Lists safety precautions to be followed, and explains how to organize a trampoline club.

103. Price, Hartley O., and Newton C. Loken, "Trampolining Stunts in Naval Aviation," *Scholastic Coach,* 12:6:12 (February, 1943). Thirty good pictures and descriptions of stunts. Discusses the values of gymnastics and trampolining in relation to the Navy physical fitness program.*

104. ————, "Dual Trampolining for Conditioning," *Scholastic Coach,* 12:7:12 (March, 1943). Thirty photographs describing two- and three-person stunts, all adaptable for exhibition routines.*

105. Wettstone, Eugene, "Tips on Trampolining, America's Newest Sport," *Athletic Journal,* 22:5:11 (January, 1942). Good photographs and descriptions showing how trampolining aids both the tumbler and the diver.*

THESIS

106. Loken, Newton C. *The Order and Grade of Trampoline Stunts According to Their Difficulty.* Master's thesis, University of Michigan, 1946, pp. 108. Results of questionnaires that were sent to leading authorities in regard to this new gymnastic event. Author learned that there was reasonable agreement on the degree of the first and last three stunts in each of five progressive stages of difficulty (ten stunts in each classification). The consensus was that trampoline scoring should be similar to that of tumbling rather than of diving.*

TUMBLING

BOOKS

107. Cotteral, Bonnie and Donnie. *The Teaching of Stunts and Tumbling.* New York: A. S. Barnes and Company, 1936, pp. 337. Excellent for both single and combination tumbling. Most complete history of tumbling that was found in the literature.*

108. ————. *Tumbling, Pyramid Building, and Stunts for Girls and Women.* New York: A. S. Barnes and Company, 1927. Not reviewed.

109. Gwathemey, James T. *Tumbling for Amateurs.* New York: American Sports Publishing Company, 1930. Well illustrated for singles, doubles, and triples in tumbling; but descriptions are somewhat vague.

110. Harby, S. F. *Tumbling for Students and Teachers.* Philadelphia: Saunders and Company, 1932, pp. 212. Excellent for single and combination tumbling both from the standpoint of the beginner and the more advanced student.*

111. Horne, Virginia. *Stunts and Tumbling for Girls.* New York: A. S. Barnes and Company, 1943, pp. 220. Excellent pictures and descriptions of single and double tumbling, pyramids, and class administration.*

112. La Porte, W. R., and A. Renner. *The Tumbler's Manual.* New York:

Prentice-Hall, Inc., 1938, pp. 122. Diagrams drawn from movies that had been corrected by national authorities. Very good description of single and double tumbling as well as of the teaching of groups.*

113. McClow, L. L. *Tumbling Illustrated.* New York: A. S. Barnes and Company, 1931, pp. 212. Should be in everyone's library. Excellent for all forms of comedy and exhibitional tumbling.*

114. Pearl, N. H., and H. E. Brown. *Health by Stunts.* New York: The Macmillan Company, 1927. Numerous individual and companion stunts described. Excellent for elementary school use.*

115. Stecher, W. A. *German-American System of Gymnastics.* Boston: Lee and Shepherd, 1896. Not reviewed.

116. ————. *The Theory and Practice of Educational Gymnastics.* Philadelphia: McVey and Company, 1918. Not reviewed.

117. *Tumbling.* Chicago: Chicago Park District. Not reviewed.

118. *U. S. War Department Manual, FM 21-20.* Washington: U. S. Government Printing Office, 1946, pp. 392. Approximately thirty pages are devoted to lucid explanations of both single and combination tumbling stunts of elementary and intermediate nature.*

PERIODICALS

119. "Flip Wolfe: Ace Tumbler," *Life,* 10:12:51 (March 24, 1941). Action photographs showing advanced tumbling.

120. "June Preisser Makes Tumbling an Art," *Life,* 8:14:70 (April 1, 1940). Good action photographs showing aerial kick-overs.

121. "Pretzel Girl; Tumbler Defies Laws of Both Physics and Anatomy," *Life,* 14:24:64 (June 14, 1943). Action pictures of fifteen-year-old Bonnie Nebelong doing contortion work.

122. Atwell, A. A., "A Different Approach to Tumbling and Stunts," *J. of Health and Physical Education,* 9:3:142 (March, 1938). Suggests methods of organizing tumbling classes through squads of similar ability. Teaches creativity with pyramids the same as other teachers do with the dance.

123. Barkdoll, O. R., "Aids for the Beginning Tumbler," *J. of Health and Physical Education,* 12:8:13 (April, 1943). Splendid suggestions for home-made equipment to assist in the learning of the cartwheel, back handspring, somersault, and front handspring. Highly recommended.*

124. ————, "Aids for the Beginning Tumbler," *Scholastic Coach,* 12:7:16 (March, 1943). Describes unique equipment for the teaching of the head balance, hand balance, and hand walk.*

125. Beyer, Erwin F., "Campus Acrobatics," *Popular Mechanics,* 86:124:128 (September, 1946). Shows how tumbling is taught with the group method; similar to that of assembly plant operation in industry. Very novel group diving stunt illustrated.*

126. Cotteral, Bonnie and Donnie, "The Romping Rompers," *J. of Health and Physical Education,* 1:5:16 (May, 1930). Description of a tumbling program for grade school children. Includes music, costumes, scenery, and routines.

127. Hall, Bowman N., "Organization for Tumbling," *Scholastic Coach,* 15:4:30 (December, 1945). Explains the values of tumbling and lists progressive stunts. Thorough techniques.*

128. Hull, Harry R., "Mat Work in High Schools," *School (Sec. Ed.),* 30:5:432 (January, 1942). Good instruction for fundamental tumbling from the front roll through the back handspring and back somersault. Also, valuable remarks regarding the administration of a tumbling class.*

129. Lockhart, Aileene, "Tumbling; An Activity in the Junior High School Club Program," *J. of Health and Physical Education,* 7:3:91 (March, 1936). Shows how a girls' tumbling club was organized in the Greenville, Texas, Junior High School.

130. McCulloch, J. H., "Introductory Exercises to Tumbling," *J. of Health and Physical Education,* 1:10:40 (December, 1930). Elementary calisthenic movements given as a warm-up prior to tumbling stunts.

131. McMillen, T. C., "A Gymnastic Program," *School Activities,* 8:5:215 (January, 1937). Suggests a simple program that can be learned in a comparatively short time when preparing for a demonstration. Pyramids, elephant leaping, and tumbling are considered.

132. Peary, G. Darwin, "Tumbling—A Sport for Girls," *School Activities,* 14:5:184 (January, 1943). Tells of the value of tumbling for the girls in Salinas, California, Junior College. Some listed were: (1) improvement of figures, (2) wholesome companionship, (3) the tumbling club was in demand for entertaining the student body.

133. Price, Hartley O., "Tumbling Hints," *Athletic Journal,* 17:7:16 (March, 1937). Very advanced tumbling stunts such as twisting somersaults. Numerous general suggestions.

134. ————, "Tumbling and Stumbling Safely," *J. of Health and Physical Education,* 13:9:531 (November, 1942). Shows the contributions of gymnastics toward wartime fitness. Describes various ways of falling properly.

135. ————, "Elementary Balancing and Tumbling," *J. of Health and Physical Education,* 9:2:100 (February, 1938). Pictures and techniques of elementary tumbling stunts such as the back and forward rolls, head balance, cartwheel, hand balance, and handsprings.*

136. ————, "Advanced Tumbling," *Athletic Journal,* 17:6:11 (February, 1937). A background of amateur tumbling in America, and suggestions for learning various somersaults.*

137. ————, "More About Advanced Tumbling," *Athletic Journal,* 17:8:20 (April, 1937). Shows how to develop advanced routines with tinsicas, brandies, baronies, butterflies, etc.*

138. Rives, William T., "Flip Flap Champ," *Colliers,* February 21, 1948. Good pictures of Jo Ann Matthews, national girls' tumbling champion, in action.

139. Streit, W. K., "A Stunt Meet for Elementary School Boys," *J. of Health and Physical Education,* 10:10:584 (December, 1939). Describes the administration of a tumbling and apparatus stunt meet held in the Cincinnati elementary schools.

140. Varonok, Samuel H., "Value of Tumbling," *Hygeia,* 11:4:360 (April, 1933). Explains how a tumbling club was formed at the Berriman Junior High School of Brooklyn.

141. Wettstone, Eugene, "Introduction to Schoolboy Tumbling," *Scholastic Coach,* 10:6:11 (February, 1941). Offers practical suggestions as to methods that will promote tumbling. Lists ways of using mats and lunging belts for protection.*

142. ————, "Advanced Schoolboy Tumbling," *Scholastic Coach,* 10:8:11 (April, 1941). Believes that somersaults divide the advanced from the beginning tumblers. Gives techniques for somersaults, Arabian tumbling, twists, and routines.*

143. ————, "Elementary Schoolboy Tumbling," *Scholastic Coach,* 10:7:21 (March, 1941). Words and picture explanations of such stunts as forward and backward rolls, handspring, round-off, and somersaults. Routines also covered.*

144. ———, "Cheerleaders Should Be Acrobats," *Scholastic Coach*, 12:1:15 (September, 1942). Excellent illustrations and suggestions for the improvement of cheerleading through tumbling.*

THESES

145. Eggleston, Hiram E. *A Survey of Tumbling and Pyramid Building in the Physical Education Program of California High Schools.* Master's thesis, University of Southern California, 1935, pp. 92. A questionnaire was sent to 150 secondary schools in California. Found that 98 percent of the faculty held a favorable attitude towards tumbling and pyramids. They also believed that it held slight danger, and that it fulfilled many of our physical education objectives. Eighty-five percent of the schools do not allow coeducational tumbling classes, and 80 percent do not allow mixed tumbling in demonstrations.

146. Forsell, Herbert G. *A Study to Show the Effect of a Program of Apparatus Work on Individual Fitness, and a Correlation of the Physical Fitness Index and the Scholastic Rating of 20 Freshmen and 20 Upperclassmen at M. I. T.* Master's thesis, Boston University, 1938. Not reviewed.

147. Frasier, Ruth A. *A Comparative Study of the Terminology of Stunts and Tumbling for Intermediate Grades.* Master's thesis, University of Iowa, 1945, pp. 174. Due to the wide variety of tumbling nomenclature, this study attempted to determine which names of stunts registered best with the junior high school girls. A total of 250 girls was used, and the nomenclature from 18 leading tumbling textbooks. It was concluded that "although authors do not agree on stunt names, there is enough similarity among the majority of titles so that the reader familiar with the literature can identify stunts of like motion or body parts involved. However, it raises an unnecessary obstacle to the untrained teacher."

148. Heidloff, Raymond C. *A Logical Application of Physics to Selected Tumbling Stunts.* Master's thesis, Springfield College, 1938, pp. 103. Applied physics principles and cinematography used to facilitate a better understanding of the exact techniques of teaching the front and back handsprings and front and back tuck somersaults. Excellent blue prints that show the correct methods as portrayed by two champions.*

149. Kantor, Julius A. *An Abbreviated Test of Gymnastic Ability.* Master's thesis, New York University, 1934. Not reviewed.

150. Nagle, John L. *The ABCD's of Tumbling.* Master's thesis, Springfield College, 1934, pp. 129. Movies were used of 21 key tumbling exercises that are basic for advanced work in an attempt to grade the exercises objectively according to a pass or fail basis. A total of 128 single and combination stunts is described.

151. Parry, Kenneth R. *The Learning Process in Tumbling for the Elementary Grades.* Master's thesis, Springfield College, 1933, pp. 105. There were 275 Springfield elementary school boys tested as well as 196 Knoxville, Tennessee, boys, all from the 4th, 5th, and 6th grades. They were given three months of practice, one half hour a week. There was an average of 20 boys per class attempting to pass 20 stunts. The 4th grade showed the greatest improvement, and 6th grade, the most ability. In grades 5 and 6 the A tumblers were better in the classroom than D tumblers. The author revised his progression of stunts as a result of this study.

152. Prochaska, Lorine A. *A Study of Age, Grade Placement, and Motor Ability as Factors of Achievement in Tumbling for High School Girls.* Master's thesis, University of Southern California, 1946, pp. 79. A group

of 260 secondary school girls was given tumbling instruction, and stunts were graded according to their difficulty after getting percentages of those students passing them. T-scores were then made. Achievement in activity was found to increase up to the age of 16, and then a slight decrease was noted. The following were some of the more common stunts listed in their progressive order: forward roll, 85 percent; backward roll, 68 percent; forward roll, no hands, 53 percent; dive over two people, 41 percent; head balance, 40 percent; handstand against wall, 39 percent; fish flop, 35 percent; squat balance, 35 percent; cartwheel, 34 percent; handstand for 6 seconds, 13 percent; dive over four, 13 percent; handspring, 6 percent; walk on hands three steps, 2 percent.

153. Renner, Al. *An Illustrated, Graded, Standardized Curriculum of Group Units in Tumbling for the Secondary School Level.* Master's thesis, University of Southern California, 1936, pp. 143. Movies were used and revised by drawings by national tumbling authorities to formulate a scientific single and group tumbling curriculum. Splendid for elementary and intermediate work of this nature. This was the basis for *The Tumbler's Manual* referred to in No. 112.*

SAFETY

BOOKS

154. Seaton, Don C. *Safety in Sports.* New York: Prentice-Hall, Inc., 1948, pp. 414. One chapter is devoted to spotting on the apparatus. Much of Wettstone's material is reproduced here.*

PERIODICALS

155. Barkdoll, O. R., "Teaching Gymnastics with Home-Made Aids," *J. of Health and Physical Education,* 11:8:491 (October, 1940). Excellent photographs of unique home-made parallel bars and apparatus for teaching the hand walk and back handspring.*

156. Heidloff, Ray, "Acrobatic Citizens," *J. of Health and Physical Education,* 16:2:76 (February, 1945). Great emphasis placed on gymnastic precaution by the use of magnesium carbonate, resin, mats, lunging belts as well as both the psychological and physiological condition of the persons.*

157. Price, Hartley O., "The Art of Guarding or Spotting," *J. of Health and Physical Education,* 8:3:151 (March, 1937). Stresses the importance of building up confidence in beginners, and this is aided by careful spotting. Offers suggestions for spotting on all apparatus.*

158. ————, "Safety Procedures in Gymnastics," *Athletic Journal,* 20:6:10 (February, 1940). Photographs showing proper spotting on the horse, parallel bars, flying rings, and horizontal bar. Shows the value of chalk, safety belts, and expert spotters.*

159. Wettstone, Eugene, "Safety Devices in the Gymnasium," *J. of Health and Physical Education,* 12:2:98 (February, 1941). Should be read by all interested in gymnastics. Superior photographs of safety devices such as the hand belt, hand guards, ceiling lift, and special mats for parallel bars.*

THESES

160. Mitchel, Carl E. *Safety Devices for the Teaching of Gymnastics.* Master's thesis, University of Southern California, 1933, pp. 153. Sound and novel safety devices as practiced by gymnastic authorities on the Pacific coast. Extremely practical safety hints on the apparatus.*

Motor Learning of Highly Chosen and Unchosen Teammates

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THE traumatic effect of rejection or lack of status on the personality of some individuals is well known. Because physical education classes provide real situations of acceptance or lack of acceptance, it is important to discover the factors which are related to the status of students in physical education classes. One of the many questions which arise is the relationship between status and ability to learn a new motor skill.

PURPOSE OF THE STUDY

The purpose of this study was to determine, if possible, whether unchosen teammates differ from highly chosen teammates in learning a new motor skill. Specifically, in learning to trace the Snoddy star, do the two groups differ in (1) accuracy, (2) speed, (3) pressure applied to stylus, and (4) relationship between these factors?

METHOD OF PROCEDURE

Subjects.—The subjects were 79 freshman and sophomore women enrolled in physical education service classes at the University of California at Los Angeles. Differentiation into "highly chosen" and "unchosen" groups was made from the results of a sociometric study of 586 subjects by Breck (1) the previous semester. The 40 subjects classified as "highly chosen" in each case had been chosen by at least eight classmates in the final administration of Breck's sociometric test. The mean number of choices received by this group was 15.34 ± 4.34. The "unchosen" group consisted of 39 students who had received no choices as teammates in this test. The subjects were not aware of the basis on which they were asked to participate in the experiment.

Apparatus.—The Snoddy star has been described in previous publications (5). Briefly, it consists of a path with notched edges which is reflected in a mirror. Direct vision of the path is prevented by a shield. Contact of the tracing stylus with the edge of the path

completes a circuit and activates a Stoelting counter which records the contacts or errors.

A special tracing stylus was constructed for this experiment to measure pressure in addition to errors. Downward pressure on the stylus resulted in a completed circuit through a metronome and a Stoelting counter. The metronome interrupted this circuit at one-half second intervals. Thus, twenty seconds of continuous pressure would be recorded as a raw score of 40. In this way, the length of time pressure was applied was measured rather than the amount of pressure being applied.

Speed was measured in seconds by a stop watch. In order to minimize distracting sounds, the counters were kept in an insulated drawer and the metronome was in a nearby closet.

Testing procedure.—The tests were administered to the subjects individually. The same procedure was followed with each subject. The tester described and demonstrated the task to be performed. The instructions were to go as quickly as possible with as few errors as possible. After each trial the subject was given her score in accuracy and speed and was told to try for equal scores in the two measures. Pressure scores were not mentioned. Twenty tracings of the star were made by each subject. Accuracy, speed, and length of time pressure was applied were recorded after each trial. In addition, a record was made of any comments by the subject as to method of attack and attitude toward the task. The tester also made a subjective judgment as to whether the subject was nervous and tense or relaxed and calm.

RESULTS

The following symbols are used in reference to the data: S = speed, measured in seconds; A = accuracy, measured as number of contacts with the edge of the path (high scores in both S and A indicate poor performance). The twenty tracings of the star were considered as five trials. Each trial was the summation of four tracings: T_1 = summation of scores on first four tracings; T_2 = summation of scores on second four tracings, etc.; H group = highly chosen group; U group = unchosen group.

Pressure scores.—Raw pressure scores were negatively correlated with speed. The mean Pearson Product moment correlations were —.48 for the H group and —.35 for the U group. The faster subjects applied pressure for less time than the slower subjects. These correlations are significantly[1] different from zero (level of confidence $< .0004$).

[1] All tests of significance of difference of correlations from zero or significance of difference between correlations were based on Fisher's *z* transformation scale which converts the sampling distribution of *r* into a reasonably normal curve. $\sigma_z = \frac{1}{\sqrt{N-3}}$ For the purposes of this experiment the .05 level will be considered significant.

In order to determine whether this relationship between speed and pressure was induced by the method of measuring pressure, pressure scores were converted into scores of percent of time pressure was applied.[2] The mean correlations between the corrected pressure scores and speed were —.08 (H group) and +.07 (U group). These are not significantly different from zero. Therefore, the relationship of the raw pressure scores to speed was probably due to the method of measurement and should be corrected. In the following data "P" or "pressure" will be used for pressure scores which have been corrected for speed and therefore represent the percent of time pressure was applied.

Distribution of pressure scores.—It was observed that the standard deviations of pressure scores increased from T_1 to T_8 for both groups. The frequency discord between the distributions for the two groups on T_1 and T_8 was not significant when the chi square $(\chi)^2$ test was applied (.60 and .35 levels respectively). Inspection of the distribution showed an increasing tendency toward a bimodal distribution. To test the significance of this apparent increase in bimodality, the chi square test was applied. The combined frequencies of the two groups on T_1 did not differ significantly from a theoretical distribution based on the normal curve. The combined frequencies on T_8 differed significantly ($<$ .001 level) from a normal curve. Similarly, the frequency discord between T_1 and T_8 was significant. We may conclude from this that in both groups practice resulted in a significant shifting of scores away from the mean to the extremes.

Reliability.—Correlations of the first four old tracings with the first four even tracings, and second four odd tracings with the

TABLE I

COEFFICIENTS OF RELIABILITY OF MEASURES OF SPEED, PRESSURE AND ACCURACY

	Speed	*Pressure*	*Accuracy*
r 1st 4 odd. 1st 4 even			
H Group	.91	.92	.75
U Group	.91	.96	.69
r 2nd 4 odd. 2nd 4 even			
H Group	.96	.95*	.86
U Group	.97	.85*	.86

* These correlations are subject to error due to the tendency toward bimodality of the distribution in later trials. However, inspection of the scattergrams justifies use of them as estimates of reliability.

[2] $\frac{\text{Raw pressure score}}{2 \times \text{seconds}}$ = corrected pressure. Since the metronome beat was at one-half second intervals, this score would be equivalent to the percent of time pressure was applied.

second four even tracings were used as estimates of reliability for T_1, T_2, T_3, T_4, T_5. The coefficients of reliability were high for speed and pressure. Mean correlations were as follows: $\bar{r}_S = .94$; $\bar{r}_P = .92$; $\bar{r}_A = .79$. Table I gives these coefficients of reliability.

Mean performance.—The two groups did not differ significantly in mean speed or mean accuracy in any of the trials. When the five trials were combined the difference was still insignificant. The difference between the groups in pressure was not significant when trials were compared directly. However, the decrease in mean pressure of the H group from 44.27 in T_1 to 35.15 in T_5 was significant (.0375 level).[3]

The increase in pressure of the U group from 40.02 in T_1 to 41.15 in T_5 was insignificant. This indicates that the two groups differ in performance in pressure, since the H group used significantly less pressure at the end of the practice period than at the beginning, and the U group used approximately the same pressure at the end of the practice period as at the beginning. Means and standard deviations of speed, pressure, and accuracy are given in Table II.

TABLE II

MEANS AND STANDARD DEVIATIONS OF MEASURES OF SPEED, ACCURACY, AND PRESSURE

	T_1		T_2		T_3		T_4		T_5	
	M.	*s.d.*	*M.*	*s.d.*	*M.*	*s.d.*	*M.*	*s.d.*	*M.*	*s.d.*
Speed*										
H Gr.	181.50	69.80	120.92	36.74	107.50	33.66	100.70	29.20	93.30	25.80
U Gr.	181.90	78.20	117.75	58.50	113.85	39.15	104.50	31.68	96.50	28.20
Pressure**										
H Gr.	44.27	23.82	41.87	28.14	40.75	28.85	38.00	29.20	35.15	30.20
U Gr.	40.02	28.80	36.95	29.78	35.98	31.35	39.28	34.42	41.15	34.90
Accuracy***										
H Gr.	230.60	88.22	153.50	45.00	133.20	39.49	121.75	32.10	116.65	30.87
U Gr.	235.36	73.92	157.80	46.95	136.00	36.30	127.58	31.28	116.38	27.68

* Seconds. Low score represents high performance.
** Percent of time pressure applied.
*** Errors. Low score represents high performance.

Relationship between factors.—The two groups differed in their correlations between accuracy and percent of time pressure was applied. The H group had a mean correlation for the five trials of +.26. The equivalent correlation for the U group was —.09. This difference is statistically significant.

The mean correlations between speed and pressure and speed and

[3] Since these scores are paired variates, the appropriate formula for $SE_{\bar{d}}$ is

$$\sqrt{S.E._{T_1}^2 + S.E._{T_5}^2 - 2r_{T_1T_5}\ S.E._{T_1}\ S.E._{T_5}}$$

accuracy were not significantly different from zero for either group. Table III gives these intercorrelations and levels of significance.

TABLE III

INTERCORRELATION OF SPEED, ACCURACY, AND PRESSURE SCORES FOR HIGHLY CHOSEN AND UNCHOSEN TEAMMATES

	Speed			*Accuracy*		
	$\bar{r}$	P_1*	P_2	$\bar{r}$	P_1	P_2
Pressure						
H Gr.	−.08	.29	.13	+.26	.00	.00
U Gr.	+.07	.32		−.09	.24	
Accuracy						
H Gr.	−.09	.25	.18			
U Gr.	+.05	.52				

* P = probability of occurrence through errors of random sampling; P_1 = level of significance of difference from zero; P_2 = level of significance of difference between H gr. and U gr.

Persistence of factors.—The degree to which relative position in accuracy, speed, and pressure was maintained was estimated by correlating the scores of T_1 with T_5. The U group had a correlation of .81 between T_1 and T_5 in pressure. This is significantly higher than the equivalent correlation of .51 for the H group. The groups did not differ significantly in the persistence of speed or of accuracy. Table IV gives these correlations and the probability of the difference between the groups occurring through errors of random sampling.

TABLE IV

CORRELATIONS BETWEEN SCORES OF TRIAL 1 AND TRIAL 5 IN SPEED, ACCURACY, AND PRESSURE

	U Group	*H Group*	*P**
Pressure	.81	.51	.01
Speed	.24	.44	.32
Accuracy	.53	.64	.46

* Probability of difference occurring through errors of random sampling.

Pressure scores and estimates of nervousness.—The relationship between pressure scores and subjective estimates of nervousness which were made by the tester was estimated by a biserial correlation. Scores of subjects who had been classed as "nervous" or "unusually calm" were used: r_{bis} for H group was $.54 \pm .08$ and $.74 \pm .07$ for the U group. Since the form of the sampling distribution of r_{bis} is not known, the significance of the difference between the two correlations cannot be determined. This positive relationship between nervousness and pressure scores is substantiated by the χ^2 test when the data are considered as a fourfold table with pressure scores divided into two classifications, above the mean

and below the mean; χ^2 of H group was 10.70 (.001 level) and χ^2 of U group 15.54 (.0001 level).

CONCLUSIONS AND INTERPRETATION

Unchosen teammates do not differ significantly from highly chosen teammates in ability to improve in skill in the Snoddy Star test when performance is measured by accuracy scores and speed scores. The two groups do differ significantly in regard to the measures of percent of time pressure was applied to the stylus during the learning period. The highly chosen subjects applied pressure a smaller percent of time after practice, had a small positive relationship between pressure and accuracy, and had less persistence of relative position in pressure scores.

As practice progressed, both groups developed a bimodal distribution of pressure scores. Both groups had a positive correlation between the subjective estimates of nervousness and pressure scores.

The differences between the two groups in the measures of pressure cannot be interpreted without further research. It is suggested that investigation of the whole area of pressure and tension in relation to motor learning might prove profitable. The excellent articles by Freeman (4), Brower (2), and Davis (3) show the scope and complexity of this area.

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Mechanical Analysis of Diving

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INTRODUCTION

FANCY diving, from all aspects, is an activity involving a high degree of complex skills. An individual who wishes to become proficient in the art of diving must necessarily spend many hours a week, for many months and years, in actual practice diving off the board.

Many talented divers of today have gained this proficiency through constant practice, without adequate coaching, by trial and error method. Other talented divers have gained proficiency in diving in a shorter time, through the use of talented coaching. At best, however, even with the services of a talented diving coach, most diving skills have to be learned through the trial and error method. Visual aids such as films, or observation of good divers in action, may be used in conjunction with verbal instructions in teaching one to dive. If any other methods can be used to give the learner an insight beyond those mentioned, then the skills should be acquired a little more easily, and perhaps in less time. It is in this way that a mechanical analysis of the dives would be of some value to the coach as a teacher, and to the student as a learner.

PURPOSE

The purpose of this study is twofold. First, this is an attempt to add a little more validity to a previous study [1] done along this line, with the hope that any subsequent studies may benefit. Here, as in the previous study of this type, emphasis is given to the speed of rotation and accumulative velocity of acceleration or deceleration per second, for a variety of dives. A greater degree of validity was sought through a more accurate location of the center of gravity around which the body must rotate.

Second, an attempt was made to break down complicated dives into a mechanical analysis through charts and tables, showing how these dives are basically performed.

An abstract of a thesis for the master of arts degree presented at the State University of Iowa, at Iowa City, February, 1949.

[1] Josephine Lafler, A mechanical analysis of diving techniques. Master's thesis. State University of Iowa, 1943.

METHODS

1. *Locating the center of gravity.*—A rectangular plywood board which weighed 53½ pounds was built. On each corner an eyebolt was attached. The length of the board from the center lines of these bolts equalled 72.375 inches. The width of the board from the center lines of these bolts was forty-eight inches. The board was painted black in order to offer a better background for photographic purposes. On this black background were painted 2 two-inch white stripes, one horizontally and one vertically, which divided the board into four rectangular areas. The board was waxed heavily in order to facilitate the efforts of the divers in assuming the desired positions.

Inserted in each of the eyebolts was an eighty-pound spring scale, the accuracy of which was ascertained at the factory before being used. Attached to the other end of each scale was a rope. After leveling the board, the ropes were then tied to supports of the scaffolding.

In order to obtain the photographs from the best possible angle, a scaffold of approximately thirty feet in height was used. The board, upon which the divers were directed to lie, was centered underneath the scaffold. The photographer was placed directly above the board and from this position the photographs were taken.

In order to determine the accurate center of gravity, three divers who were members of the varsity swimming team of the State University of Iowa were selected for photographing. Each differed in stature and weight, thus giving an over-all picture of the center of gravity location. Each of the three divers was placed, in turn, with his pelvis as near the center of the board as was possible. Each then assumed a position that was described to him as a certain phase of the basic elements of dives. Thirteen various positions were assumed by each diver, the total equalling thirty-nine different pictures. Three examples of these are shown in Figures 1, 2, and 3. Figure 1 represents the entrance phase of the back dive. Figure 2 represents the tuck position of the forward somersault. Figure 3 represents the jackknife in closed position.

The thirteen phases are described as follows:

1. Back dive (entrance).
2. Forward somersault-tuck.
3. Jackknife (closed position).
4. Swan dive (near peak of dive).
5. Forward somersault (layout position).
6. Entrance position (jackknife).
7. Entrance position (forward somersault).
8. Back dive (peak).
9. Forward one-and-one-half somersault (pike swan).

Figure 1

Figure 2

Figure 3

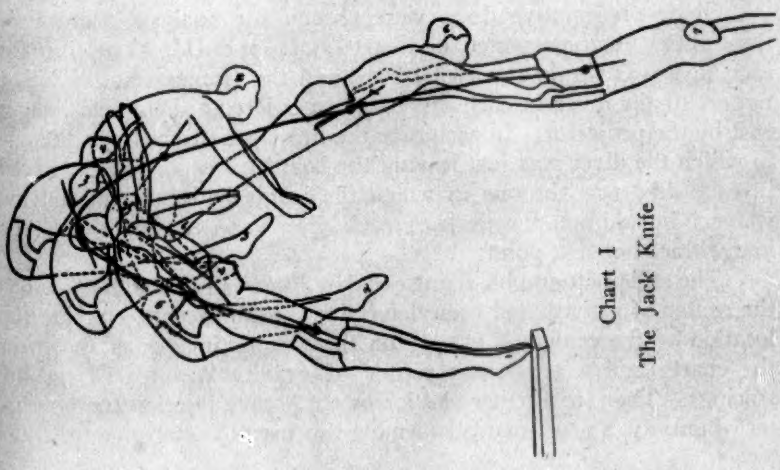

Chart I
The Jack Knife

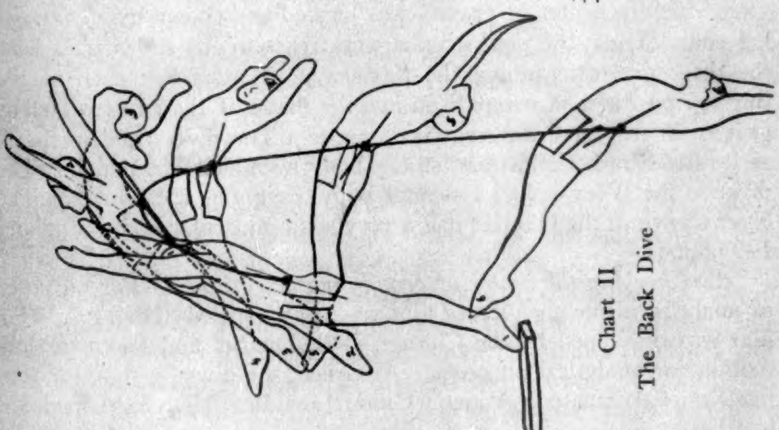

Chart II
The Back Dive

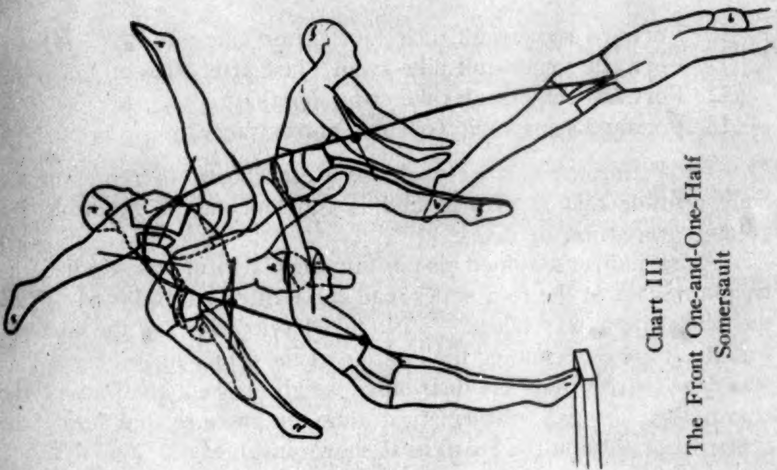

Chart III
The Front One-and-One-Half Somersault

10. Forward somersault-tuck (just after take-off).
11. Forward somersault-pike swan (just after take-off).
12. Forward somersault-pike swan (peak).
13. Forward somersault (opening for entrance).

These thirteen various positions were chosen to represent the body attitude that is present and is fundamental in executing the greater proportion of dives.

As each diver assumed his position the platform was steadied, the weight of each of the four scales read and written on the board. Then the photograph was taken. With the development of the film, all was ready for determining the location of the center of gravity. This was done by recording the distributed weight of each quadrant on the board, then using a mathematical ratio to measure and locate the center of gravity on the board as is shown in Figures 1, 2, and 3.

After the center of gravity was located and shown by a contrasting color of ink, the photographs were reassembled showing each of the three divers assuming the thirteen positions. For each of the thirteen positions, a comparison may be made of the exact center of gravity in the three different body types. The diver used in the A series had a rather short and stocky body, weighing 156 pounds. The diver in the B series had a slender body, weighing 151 pounds. The diver shown in the C series had a very solid, muscular body, weighing 190 pounds.

2. *Checking the center of gravity mathematically.*—For purposes of analysis, a moving picture film was used entitled "Diving." This film was developed by the Chicago Park District and taken in slow motion for analytical purposes. Al Green, the diver in the film, was the National Amateur Athletic Union Low Board Diving Champion in 1936.

Six representative dives were chosen for analysis. Three of these dives are represented in Charts I, II, and III. The film for each dive was slowly turned by hand and the frames counted. The figures of the diver in each dive were traced from the actual images cast by the projector. In each dive the first figure traced was the one in which the diver was just leaving the board. The last figure traced in each dive was the one in which the hands had just entered the water. In addition the peak of each dive was determined and the image traced at that point.

The still photographs, represented by Figures 1, 2, and 3, on which the center of gravity had been determined, were used to estimate the location of the center of gravity on the various images as shown in the charts and a temporary center of gravity was placed on the tracings. Then, to further check this temporary location of the center of gravity, a mathematical formula was used to determine the loca-

tion of the parabola. The formula matched each estimated location of the center of gravity in most of the figures, and varied only slightly in a few. The heavy line shown in the charts represents the parabolic curve of the center of gravity.

3. *Determining the speed of rotation.*—In order to determine the speed of rotation it was necessary to find the time that the diver was in the air, and then determine the speed that the camera was turning for that particular dive. This was necessary in that no constant speed was used for all the dives studied.

To find the time that the diver was in the air, the formula, distance fallen $= \frac{1}{2} gt^2$, was used. The distance was determined by a ratio since the height of the diver was known. The number of frames on the film was then turned by hand and counted and the speed of the film for each dive was determined.

The longitudinal axis of the diver's body was estimated for each figure of the diver and drawn in. The number of degrees that the axis rotated through was measured from each succeeding figure. Then the speed of rotation for each figure was determined by use of the formula in which the number of frames turned is divided by the speed of the film.

ANALYSIS OF THREE OF THE SIX DIVES STUDIED

Six dives were studied in the original study, but for the sake of brevity only three of the dives are offered for detailed analysis here. It was felt that this number would be sufficient to show the method used. Table IV has been included to show an overall comparison of the six dives. It should be kept in mind that the distance or height measured is from the center of gravity of the figures, and not from the board to the peak, nor from the peak to the water.

1. *The jackknife dive.*—The jackknife dive rates second in height obtained off the board as shown in Table IV. The degree of lean on the board just before the take-off is completed is the same as for the swan dive. The fact that a little less height is obtained for this dive than in the swan dive may be attributed to the different action of the arms and legs. The arms give a powerful lifting effect, but do not continue upward in a follow-through position as is true in the swan dive. In addition the legs have a reaction opposite to that executed in the swan dive, thus decreasing the full lifting effect. Further, when the body is in a jackknife position the center of gravity lies outside the body as shown in Figure 3.

Table I shows that speed of rotation rises steadily and swiftly up to Figure 5 shown on Chart I. It is here that the diver actually "opens" his jackknife and the speed of rotation decreases as the body maintains its former position and lowers to the water. In Figure 7, the speed of rotation increases again as the body whips into the posi-

tion for entrance into the water. The speed of rotation of the diver just after leaving the board is less than that shown in Table IV for the swan dive. This indicates that the position of the long axis of the diver is still similar to the take-off position. This is a decided difference compared to the findings in the forward double somersault.

The speed of rotation for the entire jackknife dive is a little greater than is the speed for the swan dive, but is less than the speed of the other four dives.

TABLE I

JACKKNIFE DIVE

Figures	*Frames*	*Degree of rotation (lean)*	*Accumulative degree*	*Speed of rotation in degrees/second*
1	0	23	0	0.00
2	10	8	31	55.33
3	10	11	42	73.33
4	14	27	69	128.57
5	20	57	126	190.00
6	16	23	149	95.23
7	13	22	171	111.67

(Speed of film—66 frames/second)

2. *The back dive.*—In the back dive the height obtained is much less than is true in the swan and the jackknife dives. The most obvious reason for this is that no running approach is used. It is also seen, in comparing the dives as shown in Table IV, that the lean just before the take-off is less than that for any of the other dives selected. The speed of rotation increases rapidly up to Figure 5 as shown in Table II. This rapid increase is due to the excessive hyperextension necessary to get into position for entrance into the water. When the height is low one might expect the speed of rotation to be less, the lean on the board and the distance traveled away from the board, greater. This seems to be a common fault when beginners attempt this dive.

The speed of rotation for the entire dive is greater than the swan

TABLE II

BACK DIVE

Figure	*Frames*	*Degree of rotation (lean)*	*Accumulative degree*	*Speed of rotation in degrees/second*
1	0	20	0	0.00
2	13	15	35	68.18
3	13	21	56	95.45
4	14	53	109	220.83
5	12	21	130	105.00
6	12	24	154	120.00

(Speed of film—59 frames/second)

or jackknife dives. This is due to the necessary hyperextension of the body for proper entrance into the water, and also because of less height.

3. *The forward one-and-one-half somersault dive.*—The forward one-and-one-half somersault is executed from a running approach as are the jackknife and the swan dives. In comparison with these two dives, the forward one-and-one-half somersault obtains less height than either one shown in Table IV. This is a result of the greater lean on the board which tends to detract from height and add to the distance traversed by the diver before entering the water. The arm and leg action are also used in such a manner that the comparable height gained in the swan and jackknife dive is impossible.

The greater amount of lean on the board is necessary to start the body rotating for the required number of degrees. It may be noticed that for the forward double somersault the lean is still greater, thus indicating that when the body is to execute a 360-degree revolution or more, the lean on the board just preceding the take-off will increase until a maximum lean is reached. The maximum amount of lean preceding a forward running dive is approximated in the forward double somersault and is possibly a little, but not a great deal, more in the forward two-and-one-half somersault.

In conjunction with the greater lean of this dive, the speed of rotation just after the take-off is significant. Table IV shows this speed of rotation to be greater at this point than it has been for the dives discussed so far. Since the body is to execute a theoretical 540-degree turn, a rapid speed of rotation is necessary. The term "theoretical" is used to emphasize that in this particular study the speed of measurement of the degrees starts from the take-off and ends before full rotation is complete. Thus the total number of degrees will be 515 and not 540 degrees as is brought out in Table III.

The total speed of rotation for the forward one-and-one-half somersault dive is greater than has been true in the previous dives. This fact is obvious in that to complete the required number of degrees rotation must be faster.

TABLE III

FORWARD ONE-AND-ONE-HALF SOMERSAULT DIVE

Figure	*Frames*	*Degree of rotation (lean)*	*Accumulative degree*	*Speed of rotation in degrees/second*
1	0	30	0	0.00
2	9	64	94	278.26
3	9	97	191	421.26
4	10	103	294	412.00
5	10	131	425	524.00
6	10	90	515	360.00

(Speed of film—40 frames/second)

TABLE IV

COMPARISON OF DIVES

Dive	*Height obtained in feet*	*Lean on board at take-off*	*Speed of rotation just after take-off in degrees per second*	*Speed of rotation in degrees per second for the entire dive*	*Angular velocity of rigid body used for purpose of comparison*
Swan Dive	4.6	23	113	112	476
Jackknife Dive	4.2	23	55	118	476
Back Dive	3.6	20	68	123	304
Forward One-and-one-half Somersault	3.7	30	278	408	544
Backward One-and-one-half Somersault	2.4	21	436	456	315
Forward Double Somersault	3.2	34	350	502	562

THE MOMENT OF FORCE ACTING UPON A SPINNING BODY

The moment of force that is present when a diver leaves the board and the subsequent reactions of the diver's body to this force, are both interesting and extremely complicated. It is interesting in that when the force of upward movement of the board is exerted upon the body, the latter responds to angular velocity depending upon the position of the center of gravity of the body at the time the body leaves the board. Thus, by finding what this angular velocity might be at the take-off of the dive, one could compare the speed of the rotation of the dive itself to the amount of initial angular velocity imparted to the body. A body tends to rotate around the center of gravity at varying speeds determined by the position of the body. With this in mind, the comparison between the initial angular velocity and the total speed of the dive would indicate to some degree, the position that the body assumed during the dive.

The problem of determining the moment of inertia after the moment of force has been found becomes extremely complicated in that the human body is subjected to many radii, which, when shortened or lengthened, would call for many solutions to the initial problem. For example, if we used an inert body such as a plank 6′ x 1′ x 2″ weighing twenty pounds the problem would be much simpler to work with than would the human body. The plank could be placed on the end of the diving board in an upright position and leaning towards the water at a certain degree, such as is the position of the diver on take-off. The diving board could be depressed and released, with the moment of force or thrust being applied to the plank. It would spin around its center of gravity for a certain period of time, reach a certain height and perform certain characteristics during its flight. Since the radius in this specific example is fixed, we could expect to get very similar results, if not identical, each time we released the depressed diving board upon which rested the plank. After a certain number of trials we could predict what would happen to the plank during its flight.

It is known that when the radius of a mass which is rotating at uniform speed around a central axis is shortened, there is an increase in the speed of the rotating body. This may be seen in common examples. One example is illustrated when a ball is tied to a string and the other end of the string attached to a stick. The ball begins to move around the stick so that it completes a revolution wherein the string is kept taut. As the string, in this case the radius, wraps around the stick it shortens and the ball begins to move at a greater speed. Another example of this principle may be demonstrated by an individual spinning around on the ball of one foot with the arms extended horizontally. As long as he maintains this position in spinning his speed is observed. Then, if he suddenly pulls his arms

into his chest, his spin is increased greatly. He has increased his angular speed by shortening the radius of the extended arms.

In the example given about the inert plank receiving a moment of force from the released diving board, the radius remains unchanged. Hence, the problem of a solution for this angular speed is comparatively simple when the same problem is applied to the human body. In the human body there is not an inert mass moving around a central axis, but the mass of the body may be at constantly changing distances from the resulting variable center of gravity. It can then be seen how complicated the problem would become in attempting a solution for the action of body changes upon the resulting moment of inertia.

The scope of this study does not include the accurate solving of these problems, but it does seem that a rough comparison of each of the dives can be worked out for study purposes. This has been done with the results listed in Table IV. When a comparison is drawn, using these figures dealing with the moment of force and moment of inertia, it must be remembered that an inert, rigid mass was used. Some points can be brought out in the use of these figures, however.

Using Table IV as a reference it is easy to see that the degree of lean is very important in determining the action of the moment of force upon a spinning body. As might be expected in the running dives, when the lean is greater the height obtained is less and the angular velocity is greater. Thus, in order to complete forward somersaulting dives a higher degree of angular velocity is necessary to successfully execute them. With the same amount of initial force with which the body leaves the board, a greater lean will insure a greater angular velocity. When the lean is greater, however, one will attain less height. The position of the body during the flight of the dive will affect the angular velocity. If the body is tucked tightly the speed of rotation will be much faster than when the body is in layout position. It is for this reason that a tuck is commonly used in attempting dives that require two or more somersaults when the height of the board is comparatively low.

In one film the swan dive and jackknife had the same degree of lean with four-tenths of a foot difference in height. This difference in height, however, was too small to cause any noticeable change in the angular velocity of 476 degrees per second. In each of these dives the height obtained was greater than for any of the other dives studied. It should also be noticed that the degree of lean at take-off was less than for any of the other forward dives.

The forward one-and-one-half somersault dive had a height of 3.7 feet with a lean at take-off of 30 degrees. The resulting angular velocity was 544 degrees per second. In comparison, the forward double somersault dive showed a height of 3.2 feet with a lean of 34

degrees and a resulting angular velocity of 562 degrees per second. Since the latter dive required a greater number of revolutions than the forward one-and-one-half somersault dive, height off the board was sacrificed by the use of a greater degree of lean, thus allowing greater angular velocity to be obtained.

When the forward double somersault dive and the forward one-and-one-half somersault dive are compared with the swan dive and the jackknife dive, it is found that more height is obtained and the lean is less in the latter two dives than is true in the former two dives. The indication is that lying somewhere between a lean of 23 degrees and 30 degrees is a range which governs the possible faults of many of the dives. For example, if a diver attempts a swan dive or jackknife and employs a lean of 26 degrees, height will be sacrificed, angular velocity increased, resulting in faulty execution of the dive or poor form in entering the water, probably heel slap. If, in attempting a forward rotating dive requiring one-and-one-half revolutions or more, less than 30 degrees' lean is employed, the height will be greater with a decreased angular velocity resulting probably in an incomplete dive. If as much as a 34-degree lean is used for the forward one-and-one-half somersault dive with a tuck, the angular velocity will be too great to insure a perfect type of dive.

In the back dive and backward one-and-one-half dive the comparison shows the same results as with the forward dives. However, since the thrust of the board and distance that it moves are estimated, these two dives cannot be compared with the other forward dives used in this study.

CONCLUSIONS

This study of the mechanical analysis of diving is limited by factors present over which there was no control. Lafler[2] brought this point out in her study. It would be more desirable if a moving picture of a diver could be taken in which the camera itself would not have to be moved. This could be done, as Lafler suggests, by putting the camera some distance from the board and by using a telescopic lens. It would further be advisable to have the pictures taken outdoors for a better lighting effect, and also to have the speed of the camera held constant at sixty-four frames per second. If these things could be done, then the mechanical analysis would be a great deal more accurate.

This study has attempted to add to the accuracy of mechanical analysis through the establishment of a more accurate center of gravity around which the speed of rotation is measured. The exact images of the diver as thrown on the screen were traced so as to give a better perspective of the diver's various positions in relation to each

[2] *Ibid.*, p. 2.

other. Tables and charts have been included in the hope that a clearer idea may be obtained of the actual factors involved in diving. The method used in solving the problems are included in the study to help crystallize the work of any subsequent study done on the mechanical analysis of diving.

Specifically, the results of this study may be listed as follows:

1. On the basis of an establishment of a more accurate center of gravity in the body, the speed of rotation for the dives selected should be more accurate.

2. The mathematical check on the method used in establishing the center of gravity showed good results.

3. The minimum amount of lean on the board, combined with full upward action of the arms, will insure the greatest possible height.

4. When the lean on the board is great, the resultant force will detract from height and add to the distance of travel away from the board.

5. When the number of degrees of rotation is increased, the lean on the board will also increase, and height will decrease.

6. In order to perfect a dive, the maximum height possible is desirable. Thus, close attention should be given to the amount of lean that a diver uses.

7. The proper use of visual aids and analytical study will be of great aid to the diving coach.

Acknowledgment

The author wishes to take this opportunity to express his deepest appreciation to Dr. C. H. McCloy for his very friendly and expert guidance throughout this investigation.

The Loss of Precision from Discarding Discrepant Data*

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INTRODUCTION

In physiological studies, it is a very common practice to make measurements in duplicate or pairs. If the two measures fail to agree "within the limits of accuracy of the method," more data are secured until there is "agreement," and the discrepant datum is discarded under the assumption that some error in the procedure has caused it to be discrepant. An alternative procedure is to discard completely the set of data including the discrepant measure and make a new set of determinations.

A procedure similar to this is commonly used in timing physical performances. For example, three or five timers secure stop-watch records of the performance of the first runner to cross the finish line, compare their records, and estimate the runner's true time from the stop-watches that show the closest agreement.

Acceptance of the philosophy used to justify these practices sometimes leads to discarding of experimental data under other conditions, or the use of special types of selected scores. The writer has for some years been interested in the possibility of errors accruing from such procedures (3, p. 42) (4, p. 24), but has been unable to find any systematic or theoretical treatment of the problem in the literature. It is true that the presentation of the statistics of error found in handbooks of physical science usually cites some mathematical criterion for rejection of huge errors, as for example the Wright and Hayfords rule (5, p. 10) to reject an observation more discrepant than 5 P.E. or 3.37σ. However, these rules, whether justified or not, do not apply to the present problem as they are to be used only when the number of observations is large. Furthermore, the types of discrepancies under consideration are much smaller than those that would be discarded by the rejection rules. In timing a runner on a hundred-yard dash, for example, they would result in accepting all times within plus or minus a half second of the mean watch time. Such discrepancies are seldom met with in actual practice, as is indeed implied by the 3.2 — 3.4σ criterion.

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METHOD

In order to examine the effect of discarding or selecting data under realistic conditions, a simple timing experiment was performed. The experimenter timed 10-second intervals with a well-adjusted 0.1 second stop watch, using as a time stimulus the movement of the sweep second hand of an electric clock. The watch was read and reset and the time recorded by an assistant, so that the experimenter never knew how well he was doing.

Apparently this observer, a person who had had extensive experience with a stop watch, had equal reaction times in starting and stopping the watch. At any rate, his mean time for 150 observations was 9.99 seconds. The standard error of the series was 0.162 seconds. Assuming that the clock ran uniformly, the deviations from true time were due to inexact technique in operating the watch, imperfect judgment of the exact instant that the clock hand crossed the 10-second mark, fluctuations in reaction time, and mechanical errors in the clutch mechanism of the watch. For the present purpose, the source of error is not important. The data are available in the form of true time (clock hand) and experimentally measured time (stop watch).

Conventional statistical methods have been used to analyze these data. There is, however, one unusual feature. In an ordinary experiment, an error deviation is the difference between an observation and the mean of a series of observations with the mean serving as an estimate of or substitute for the true score, whereas in the present case the true score is known.

RESULTS OF THE EXPERIMENT

Duplicate determinations.—The 150 serial measurements were arranged in consecutive pairs, as 1 and 2, 3 and 4, etc. The average of each pair was used as an estimate of the true 10-second time, the error deviation being the difference between estimated and true score. A second series of pairs was formed by using estimates 2 and 3, 4 and 5, up to 150 and 1. The true deviations thus obtained were grouped into six categories, defined on the basis of the discrepancy between the two members of each pair, and the standard deviations of the true errors in each category were calculated by taking the square root of the mean of the squared deviations. The results of the analysis are shown in Table I. It may be noted that one-

TABLE I

STANDARD DEVIATIONS OF TRUE ERRORS OF PAIR AVERAGES AS A FUNCTION OF DISCREPANCY BETWEEN PAIR MEMBERS

Discrepancy in seconds	.0	.1	.2	.3	.4	.5+
Number of pairs	25	43	35	22	15	10
Standard deviation (sec.)	.123	.123	.099	.099	.052	.096

half of the intra-pair discrepancy would ordinarily be considered the average deviation of the measurement.

Inspection of this table reveals that the least discrepant pairs do not give a more precise estimate of the true score than is yielded by the more discrepant pairs. This is also true when each of the two series of pairs is examined separately, and also holds for the A.D. and well as the S.D. Another point which should be mentioned is that while the S.D. of the true errors of the pair averages (which turns out to be .107 sec.) can be estimated from the S.D. of all the intra-pair discrepancies, any discarding of the more discrepant pairs would obviously result in gross inaccuracy in the estimated S.D. and give a false picture of the time measurements.

These results are understandable if the real purpose of calculating the discrepancy between members of the pairs is examined. The pairs are samples used to estimate the true 10-second mean clock time. On the average, the pairs will do this fairly well, but any particular pair selected at random is very likely to yield an estimate that is either too high or too low, just as a single determination is likely to be too high or too low. If the "high" pairs were arbitrarily discarded, the remaining data would yield an estimate considerably lower than the true time; if the "low" pairs were discarded, the estimate would average too high. Similarly, the only purpose of calculating the intra-pair discrepancy is to estimate the real error of an intra-pair mean as a predictor of the true time. Selecting pairs that show a low intra-pair discrepancy has no effect whatsoever on the true error. Such a procedure simply biases the *estimate* of the true error.

Consider two pairs, one of them composed of observations of 10.0 and 10.0 seconds, the other of observations of 9.8 and 10.2 seconds. Both predict the true mean exactly, yet the intra-pair discrepancy is zero in the one case and .04 seconds in the other. The one result is about as likely to occur as the other. In fact, in the present set of data, the latter situation was somewhat more common than the former. A single pair yields only a very crude estimate of the true error just as a single measure yields only a very crude estimate of the true time. A more precise estimate can be secured only by averaging the results of a larger number of observations, and the precision of the estimate in both cases will improve in proportion to the square root of the increase in number of observations.

Screening duplicates by a tolerance limit.—It is a fairly common practice to make duplicate measurements and reject those that fail to pass some predetermined tolerance limit. The set of data used above was re-analyzed from this point of view, systematically using several tolerance limits. The difference between the pair averages and true time was used to calculate the error, when the pairs were organized as follow:

(a) Serial pairs were accepted if the intra-pair difference was within the tolerance limit. Other pairs were ignored completely (*selected* series).

(b) Serial pairs were accepted as in (a) until one was reached that exceeded the tolerance limit. The first member of such a rejected pair was accepted, and the next one or more serial determinations was discarded, until one was reached that agreed with the first member within tolerance limits, and could thus be accepted as the other member of the pair (*purified* series).

(c) Serial pairs were accepted as in (b). In the case of a pair with intervening discarded determinations, these determinations were averaged in with the purified pair to furnish a mean score for the group (series *including discards).*

The original data were gone through according to method (a) for a tolerance of zero discrepancy and the S.D.'s were calculated. Then the original data were gone through again using a tolerance limit of .1 seconds, again using a tolerance of .2 seconds, then .3 seconds, and finally .4 seconds. Methods (b) and (c) were used in a similar fashion.

TABLE II

Error Deviations of Pair Means from True Time When Pairs Are Selected by Different Tolerance Criteria

Tolerance (sec.)	.0	.1	.2	.3	.4
(a) S.D. (selected)	.123	.130	.114	.108	.104
Proportion selected	7%	49%	69%	82%	93%
(b) S.D. (purified)	.162	.141	.133	.113	.107
(c) S.D. (with discards)	.071	.102	.102	.096	.101

The errors of the three methods are given in Table II. "Selected" pairs yield slightly less error than "purified" pairs, although the difference is not in any case statistically significant. When the "discards" are averaged in with the "purified" data, the error is significantly reduced, as would be expected from statistical theory, because each "purified pair with discards" has more determinations than the "purified pair," and the discards, being rejected only because they failed to agree with a randomly selected pair member, actually predict the true score just as validly as the accepted scores. The error deviations with method (c) are significantly lower than the "purified" deviations, the "t" rations ranging from 2.5 to 5.6.

Using selected pairs (a) or purified pairs (b), the more rigorous that tolerance, the greater the error. The reason for this is not difficult to see. With a tolerance of zero, the pairs are necessarily composed of identical members, and the error of these pairs in predicting true time is exactly the same as the error of single determinations in predicting true scores, except for chance variation due to the smaller number of determinations available in the case of selected

data. With the most lenient tolerance, the pairs are almost identical with entirely unselected pairs and the error approaches the magnitude of the error obtained with unselected pairs. Intermediate tolerances yield intermediate magnitudes of error.

In the case of purified pairs with discards (c) we are no longer dealing with pairs, although the pair situation is closely approximated at the condition of most lenient tolerance. As the tolerance is made progressively more rigorous, the number of instances in which a larger group of scores substitutes for a pair is progressively increased, and at the same time the number of members in each group is increased because more data are passed over before a duplicate (within tolerance limits) of the original pair member is reached. With the most rigorous tolerance, the number of observations in a group becomes very large. The logical limit in this case would be the error of a group composed of *all* the determinations, which predict true time with a S.D. of only .013 seconds. The practical use of method (c) would be inadvisable because any particular set of measures would involve from two to some indefinite, large number of determinations, and the accuracy of a particular set of data would vary tremendously. It would be much better to systematically use groups of six serial determinations, which would theoretically result in more uniform accuracy and would be somewhat more accurate on the average than method (c).

Use of groups of three.—The original serial time estimates were arranged in groups of three as follows:

(1) Numbers 1, 2, and 3; 4, 5, and 6; ....148, 149 and 150
(2) Numbers 2, 3, and 4; 5, 6, and 7; ....149, 150, and 1.
(3) Numbers 2, 4, and 5; 6, 7, and 8; ....150, 1 and 2.

The resulting three series of 50 triplets each were intercorrelated of course, since one number of a particular triplet was always in common for each of the series. Nevertheless, this intercorrelation was by no means unity; consequently, the working up of the three series separately gave a more dependable estimate of the parameters than would have been furnished by a single series. The three sets of standard deviations thus obtained from some particular method of analysis were averaged geometrically.

The first method used was to select the "closest" two of the three measures in each triplet, average these, and determine the standard error of the pair means as predictors of true clock time. The S.D. turned out to be .131 seconds, as compared with the considerably smaller S.D. of .107 which was obtained when the first two members of each triplet were used without any selection.

Using the average of all the data, selected *and* discarded (i.e., using all three numbers of each triplet) the S.D. was only .084, a degree of improvement which is quite close to the reduction in error

theoretically expected when using samples of $n = 3$ as compared with $n = 2$. Here again, selection of data on the basis of close agreement between successive measurements *increased,* rather than decreased, the true error of the measurement. A more dramatic demonstration of the same principle occurs when the two most *discrepant* measures in each triplet are used. When this was done, the S.D. turned out to be .087 seconds, a much more precise estimate than when the "closest" two were used.

The use of the middlemost score in each triplet resulted in an S.D. of .112 seconds, considerably poorer than the .084 second error when the mean of three measures was used, but much better than the .162 second error that resulted when a single measure was selected at random from each triplet.

Use of groups of five.—In order to demonstrate that the foregoing results are not uniquely characteristic of pairs of triplets, the same method was employed for setting up five series of quintuplets and the S.D.'s averaged geometrically as before.

Using the mean of each quintuplet as a reference point, one or more members were discarded if they exceeded a predetermined tolerance limit, and the mean of the five or of the remaining members of the original five was used as a predictor of the 10-second clock time. The results appear in Table III, which is constructed somewhat differently than Table II in that the columns represent class-intervals of tolerance.

TABLE III

ERROR DEVIATIONS OF QUINTUPLET MEANS FROM TRUE TIME WHEN THE SAMPLES ARE PURIFIED BY DISCARDING DISCREPANT DATA

Tolerance (sec.)	.05	.10	.15	.20	.25	.30	.35
Percent of total quintuplets	4	12	12	33	20	12	7
S.D. from true time (unselected)	.083	.091	.079	.047	.052	.075	.048
S.D. after purification	.091	.099	.102	.069	.087	.137	.113

Here again the experimental results show that the means of groups containing discrepant measurements (discrepant in that they deviate from the sample or quintuplet means) are fully as effective in predicting true time as are the means of groups that contain only consistent data. Furthermore, the discarding of the discrepant measures lowers the precision of the prediction. A purified sample contains fewer measures than the original unpurified sample; decreasing N increases the error of the sample mean quite independently of the fact that discarding the discrepant measure has decreased the sample standard deviation.

It is true that the within-sample variance furnishes the only data for estimating, from the sample, the error of the sample mean. However, it makes this estimate indirectly rather than directly.

What is actually estimated is the *parameter*, i.e., the S.D. of the population of sample means of which this particular sample is only the one member. In the present case, the parameter happens to be known; it is the S.D. of the deviations of the means from true time, namely .064 sec. As estimated by the geometric mean of the within-sample S.D., it is .066, and would have been exactly in agreement if the distributions had been entirely normal. Nevertheless, there is no causal relation between the sample S.D. and the magnitude of the sample mean or its deviation from the constant true mean. Not only is there no causal relation, but no relation at all. They are quite uncorrelated, as may be seen in Table I (pairs) and Table IV (quintuplets), just as theoretically expected according to the mathematical derivation of Fisher (1, pp. 92-94).

TABLE IV

ERROR DEVIATIONS OF QUINTUPLET MEANS FROM TRUE TIME AS A FUNCTION OF THE WITHIN-SAMPLE STANDARD DEVIATION

S.D. within-samples	.04	.06	.08	.10	.12	.14	.16	.18	.20
S.D. of means from true time	.086	.093	.072	.089	.048	.058	.053	.065	.044

Use of rejection rules.—The present data are far too limited to permit a test of the rules that call for rejection of a datum when the series of measurements is large and the discrepancy is greater than 5 P.E. They can be used to test the value of Goodwin's rule (2, p. 21): When the number of observations is small, reject any observation that deviates more than 4 A.D. from the sample mean, the mean and A.D. being computed with the omission of the doubtful observation. Applying this rule to the quintuplets, 14.7 percent were found to contain measures that should be rejected. The deviations of their means from the true time averaged .039 seconds before purification and .137 after purification. In every case but one, the purified mean showed a greater error. It may be noted that Goodwin offered no justification for his rule in terms of statistical theory, and the classical work on the error of a mean was probably not known to him since the original copyright of his book is dated 1908.

DISCUSSION

Modern statistical theory visualizes the statistics of a sample of a population of measurements as predictors or estimates of the "true" or parametric statistics of the total population. In general, these parameters are not known to the experimenter, who consequently secures a *sample* of the population and estimates the parameter mean and the parametric distribution of the errors of sample means. In most circumstances the sample S.D. (or s) is a valid measure of the S.D. (σ) of the parametric distribution of means of sam-

ples utilizing the same number of measurements as used in the sample, but the error of a particular sample mean is uncorrelated with the S.D. of the measurements within that sample. Because of this zero correlation, the occurrence of a large S.D. in a sample of measurements implies only that the *parametric* distribution of sample means has a large S.D. It implies nothing at all concerning the actual deviation between that particular sample mean and the parametric mean. The best estimate of the parametric mean is the average of all the measurements included in the sample, whether variant or homogeneous.

While the independence of the sample mean and S.D. was placed on an acceptable theoretical basis by Fisher in 1925, it is usually not even mentioned in the statistical reference books used by physiologists and physical education research workers, and the consequences of this independence have not been developed to a point or in a manner that its importance warrants. It is obviously undesirable to engage in practices that are intended to *improve* accuracy when in reality these practices *decrease* accuracy.

SUMMARY AND CONCLUSIONS

Using the movement of the sweep-second hand of an electric clock as a criterion of true time, a series of consecutive 10-second measurements was made with a stop watch.

The error deviations between true time and estimates based on the mean of serial pairs was found to be unrelated to the intra-pair deviations, in agreement with statistical theory, and the discarding of discrepant data on the basis of tolerance limits for reproducibility of serial measures did not improve the accuracy of predicting true time from the measurements.

Similar results were secured when the data were arranged as serial triads. True time was estimated more accurately by averaging the two "wide" members of a triad than by the two congruent members. The average of all three members yielded a more accurate prediction than any method involving the discarding of discrepant measurements. Comparable results were found when the data were arranged in serial groups of five measurements. Application of Goodwin's rejection rule increased error instead of decreasing it.

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Some Facts on Swimming Cramps

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MOST opinions about swimming cramps are based on physiological theory or personal experience. It appears desirable to examine the occurrence of cramps while swimming as they actually appear in a college swimming program for men. Exhaustive analysis of the causes of swimming cramps is beyond the scope of this paper, and the primary objective is to cast more light on the following questions:

1. How frequently do cramps occur while swimming?
2. Are cramps more likely to occur in swimming classes held immediately after a normal meal?
3. Does swimming ability have any bearing on their occurrence?
4. Are fat folk as susceptible as thin ones?
5. How disabling are they?
6. Can cramps, be eliminated or minimized in the water?

PROCEDURE

From June, 1945, to June, 1946, there were about 1,400 students enrolled in the required swimming class at Georgia Tech. They swam twice a week for about eleven weeks per term, so that, as a group, they amassed a total of about 30,000 man-hours in the water during the one-year testing period. All classes had identical work and identical instruction except in regard to the prevention of cramps. It is our experience that cramps can usually be anticipated from a fraction of a second to several seconds before they actually occur. This is called the "prodromal" state, and is usually heralded by a premonitory twinge. If the affected muscle is fully extended immediately after the warning twinge the total cramp will be much less painful, and will disappear much sooner than if only the traditional corrective procedures of rubbing and kneading are followed. We alternated instruction, teaching one class the preventive and the corrective procedures, and the next class only the corrective procedures.

Sample Record Card

NAME Jones, T. L. Hour (8:30)
Fat Plump—(Average) Thin Skinny
Preventive (Corrective)
Water 80 *Temperature* 86 Air
Location Pectoral
Duration Painful 0 Annoying 5 min.
Return no
Swim ability Good (Average) Poor

RESULTS

Frequency of Occurrence.—A total of only 63 cramps occurred during the entire year. Thirty of these occurred in the group taught to correct the cramp, and 33 occurred in the group taught to prevent the cramp. In view of the fact that one of our swimming tests requires that the swimmer remain in deep water for forty-five minutes with wrists tied behind the back, and another, for the same length of time with the legs tied to the waist, Buddha style, conditions were probably more conducive to the development of cramps than would occur in normal recreational swimming.

Disability of Cramps.—Not one of our swimmers was forced to the side of the pool because of cramps. We stress the desirability of learning to handle cramps in the comparative safety of our pool, rather than waiting until one is facing a real emergency on his own, in the ocean. Our better swimmers take a maximum inhalation, then place their faces in the water, the better to pay undivided attention to the rapid elimination of the cramp. Our poorer swimmers swim on their backs while working on the muscle. They do this because it enables them to remain in direct contact with the air, in spite of the increased probabilities of nosefuls of water.

Muscles Involved in Cramping.—Grouped by frequencies cramps appeared as follows: 31, calf; 8, foot; 5, forearm; 4, hand; 4, quadriceps; 4, hamstrings; 2, triceps; 2, pectorals; one, neck flexor; one, gluteal; one, biceps. These figures total 63.

Stomach Cramps.—As an interesting sidelight we have made it a practice to ask at all of our classes if any student had ever had a stomach cramp *while swimming.* To date, after questioning over 10,000 boys, we have not encountered one person who has had one, or one person who claims to have actually seen one. There have been a few who "knew a person who knew a person," etc.

In many years' experience with swimming and swimming men the writer has never seen one nor met a dependable swimming man who has seen one. This is amazing, to say the least, in view of the large number of drownings allegedly caused by stomach cramps. Only a very brave diagnostician would dare to try to differentiate between indigestion, heart failure, skeletal cramp, stomach cramp, choking on water or regurgitated food, simple lack of swimming skill, and a host of other things which produce a common ending—drowning, or a near drowning.

It is true that abdominal cramps may make breathing difficult and possibly painful, but proper use of the arms and legs in the water will get the face out, and from then on the swimmer is in the same position as the man who gets cramps on land. It is so easy to diagnose any difficulty in the water as "stomach cramps," and so few competent observers have the opportunity to collect evi-

dence, that it seems safe to say that there is little proof that stomach cramps are a hazard in swimming, and that many other factors are much more likely suspects. It appears probable that we have been perpetuating, unthinkingly, an invention of newspaper writers, which is no more than a notion, educed by untrained observers, based on the flimsiest of evidence.

Prevention or Correction.—Anticipating the total cramp (after the warning twinge) and stretching the affected muscle *before* it shortens, eliminates practically all of the pain, and much of the probability of return. A total of 27 out of 33 of those who anticipated the cramp had no pain, but 30 out of 30 of those who allowed the muscle to cramp before working on it had real pain. A total of 24 out of 33 "anticipators" had no return, and 15 out of 30 who allowed it to cramp had no return.

Degree of Pain.—Anticipating the total cramp made the average "annoying" duration a little less than three minutes, with the "painful" cramps lasting less than a minute. Failing to anticipate it and acting accordingly made the average painful phase nearly four minutes, and the average annoying phase nearly eight minutes. "Painful" may be defined as that period when the swimmer is *sure* that he would be better off on the side of the pool than in deep water, and "annoying" is that period when there is some interference with sustaining or progressing motions. Such figures are so subjective as to be valueless in themselves, but are of considerable value in emphasizing prevention.

Water Temperatures.—Cramps occur as follows in the various water temperatures:

Degrees	78	79	80	81	82
Cramps	1	4	26	24	8

While it would have been very interesting to introduce a wide range of water temperatures, the effect of either unduly high or low temperatures on the whole aquatic program would have been undesirable. Our pool gets very heavy use from physical training classes, varsity teams, and recreational swimming, and we have found it best to keep the temperature at 80 or 81 degrees to please the greatest number of persons. Ninety percent of the time the water will be at this temperature, with occasional drops down to 78 or increases up to 84, usually corrected in a few hours.

Influence of Fat on Cramping.—According to the very subjective classification system we used, the distribution was as follows:

Classifications	*Fat*	*Plump*	*Average*	*Thin*	*Skinny*
Cramp frequencies	1	14	20	24	4
Cramp frequencies by percentages	1.5%	22.2%	31.8%	38.1%	6.3%
Classification percentages in general student population	3%	15%	45%	31%	6%

It is regrettable that we did not use the Sheldon Somatotyping Technique for this data, although our total number of cramps is so small that probably no valid conclusions can be drawn to justify positive statements.

Influence of Swimming Ability on Cramps.—Swimming ability affects cramps as follows:

Classifications	*Good*	*Average*	*Poor*
Cramp frequencies	12	34	17
Cramp frequencies by percentages	19%	51%	37%
Grade distribution in whole class	36%	46%	18%

With all manner of objectives to choose from such as speed, strokes, lifesaving, etc., and with swimmers developing at different rates during the course, it is very difficult to evaluate their ability accurately. We use their final alphabetical grades as standards, considering AA and A as good, B or C as average, and D or F as poor.

Air Temperatures.—Our poor heating system produces rapid fluctuations with very wide variations from water level to ceiling. These temperatures were taken six feet above water level.

Air temperatures	80	83	85	86	87	88	94	95	100
Cramp frequencies	6	11	10	16	4	2	3	1	1

Swimming after Eating.—Cramps occur after eating as follows:

Class hour	8:00	9:00	10:00	1:00	2:00	3:00
Cramp occurrence	7	14	10	11	5	16

Even swimming a mile with clothes on, or treading water with hands tied behind the back for forty-five minutes, produced no appreciable effects from swimming immediately after eating. This was particularly interesting, as questioning shows that our college freshmen eat about the same meals as the average beach crowd with much emphasis on hotdogs, hamburgers, etc. We advised no change in eating habits except preceding an event like the 300-yard swim for time. For this event much nausea was avoided if swimmers skipped the preceding meal, regardless of the class hour. No nausea at all occurred in the swimming classes except in connection with the 300-yard swim for time.

CONCLUSIONS

1. Cramps are not very likely to occur under usual indoor bathing conditions, and are of little importance to a trained swimmer unless speed or power is required.

2. Anticipating a cramp and stretching the threatened muscle *before* it has time to shorten will make the swimmer much more comfortable in the water.

3. The majority of swimming cramps will probably occur in the calf of the leg, and the remedy is to straighten the knee and hook the ankle.

4. Stomach cramps are probably greatly overrated as a factor in drowning.

5.. There is little evidence that the amount of fat has any bearing on the development of cramps while swimming, as practiced at Georgia Tech.

6. Swimming ability is apparently not much of a factor, though our scanty data indicate that poorer swimmers are slightly more likely to get cramps than better swimmers.

7. Minor variations of water temperatures within the range of 78 to 82 degrees apparently have no effect on cramps, at least in indoor swimming.

8. Swimming directly after meals has no harmful effects on college indoor swimmers except when speed swimming is required.

Book Review

The Varieties of Delinquent Youth. William H. Sheldon. New York: Harper and Bros., 1949. 899 pages, $8.00.

Dr. Sheldon's latest book should be of interest to every advanced student in the professional field of education and especially those in the area of psychology, physical education, and recreation. In this volume he presents a study of 200 young men whose lives and families are followed through approximately eight years, 1939-1946. They were youths that had been referred to the Hayden Good Will Inn, a South Boston social agency.

The method of presentation of this biographical material is good and should prove stimulating to educators in the area of psychology and health. The author has attempted to get at the basis of human behavior by use of the case-study technique. The study is an experiment in psychological as well as biological method. Psychology is brought back "into the theatre of human life." This is done by describing and explaining human beings as whole entities, not reflexes, not central or peripheral fragments, not abstracts. The individual's immediate physical condition and developmental structure are studied together with his medical record, physiological history, mental history, school achievement, I.Q. record, a history of his social relations, opportunities, achievements, and failures.

A complete study has been made of each individual in terms of his physical, emotional, mental, and social being. In searching for the basis of human behavior, Dr. Sheldon has gathered necessary data on each personality, and assembled it so that it may be considered in relationship to the structure of the person. The book holds that "all that you are is a natural explanation of the way you were made." The book does not pretend to suggest that man is entirely the results of nature, but it does hold that basic qualities making up the individual determine to a large extent the behavior in society. The degree to which the basic constitution influences personality and human activity is modified by environment.

Of particular interest to research workers in physical education is Sheldon's discussion regarding prominent sports people and their achievements in terms of variances in body build. The finding that mesomorphy gives definite support to athletic ability is illustrated by Sheldon's story describing his long hunt to find a major league baseball player who did not have an extremely high degree of mesomorphy. In short, athletic behavior as well as any other physical, mental, or social behavior depends to a great extent upon those qualities an individual is endowed with. In this connection, *The Varieties of Delinquent Youth* provokes considerable thought relative to the intricate and basic nature of human behavior.

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Research Abstracts

Prepared by the

RESEARCH ABSTRACTS COMMITTEE OF THE
NATIONAL COUNCIL OF THE RESEARCH SECTION
CAROLYN W. BOOKWALTER, *Chairman*

ANATOMY AND PHYSIOLOGY

20. Autio, L., O. Eränkö, and E. Jalavisto. Vasomotor reactions in Valsalva's experiment. (An electrocardiographic study with reference to the effect of smoking.) *Acta Physiol. Scandin.,* 17(2, 3): 131-149 (1949).

Thirteen habitual smokers and 12 non-smokers were used. Valsalva's "experiment" consisted in blowing against a manometer for 30 sec., keeping pressure at 40-50mm. Hg. Three ECG leads were used simultaneously. Virginian tobacco cigarettes were used for smoking. Subjects were instructed to inhale the smoke. Smoking as a rule did not affect the resting pulse rate in the "non-smokers," but caused a definite rise (16 beats/min.) in habitual smokers.

The authors postulate a theory that probably only those people who are stimulated by smoking as evidenced by an increase in pulse rate become habitual smokers; the others have no reasons for becoming smokers.

As to ECG, a significant correlation was found between the heart response and the height of P and T waves. There was no effect of smoking upon the axis deviation.—*P. V. Karpovich.*

21. Gray, Donald J., and Ernest D. Gardner. Prenatal development of the human knee and superior tibiofibular joints. *Am. J. Anat.,* 86:2 (March, 1950).

The knee and superior tibiofibular joints were studied in a series of 45 human embryos and fetuses ranging in age from 6 weeks to term. The unchondrified blastema between the tibial and femoral cartilages becomes thinned to form an interzone by 7½ weeks. Adjacent mesenchyme become intra-articular and the menisci and cruciate ligaments arise from it at about 8 weeks of development. Their early appearance lends support to the thesis that the responsible factors are primarily genetic. Cavities, fairly extensive by 9 weeks soon become lined by typical synovial tissue. This is characterized by surface cells of variable arrangement and by subjacent connective tissue containing vascular networks. It covers neither the articular cartilages nor the articular portions of the menisci. A single cavity is formed by 14 weeks or soon thereafter. Vascularization of the cartilaginous epiphyses begins by 12 weeks and ossification centers appear in them by term. Villi first appear between 11 and 12 weeks. Fat is present as isolated cells at 17 weeks and as lobules by 18 weeks.

A fabella, first present at 14 weeks, occurred inconstantly in older specimens. The superficial prepatellar bursa appeared at 11 weeks, and the semimembranosal and anserinal bursae at 12 weeks. The development of the superior tibiofibular joint, although lagging somewhat behind it, is similar to that of the knee.—*The Wistar Institute.*

22. Jongbloed, J. An artificial heart and lung. *Mod. Med.,* 18:3 (Feb. 1, 1950).

An artificial, temporary heart and lung, capable of delivering about 4

liters of adequately oxygenated blood per minute has been satisfactorily used on dogs. No significant changes in EKG have been noticed while heart chambers were empty for several hours, and heart, lungs and other organs returned to normal function after the operation.

Diagram and complete description of this artificial heart-lung are given in the article.—*A. C. Kelly.*

23. Reynolds, E. L. The fat bone index as a sex-differentiating character in man. *Human Biology,* 21:3 (Sept., 1949).

The relation of fat and bone was calculated and compared on 505 subjects ranging from childhood to adulthood. On each subject, an anteroposterior roentgenogram of left leg was taken at a six-foot focal film distance. On x-ray film, measurements of tissue breadths were taken across level of greatest width of calf. Fat breadth represents combined thickness of superficial adipose tissue (plus skin), medial and lateral; bone breadth represents the thickness of tibia plus fibula at this same level. From these measurements, the following fat/bone index was derived. $\frac{\text{Breadth of fat in mm.}}{\text{Breadth of bone in mm.}} \times 100.$

The index tends to decrease with age in males, increase with age in females at each age level, the significance of the difference between the sexes increasing with age. In the adult, the fat/bone index differentiates the sexes with 90 percent accuracy, and in children with about 70 percent accuracy.—*D. B. Van Dalen.*

24. Wolfe, J. B., and Mueller, G. W. The heart of the athlete. *The Physical Educator,* 6:2 (May, 1949).

A study of the effects of long-term intensive athletics on the cardiovascular system undertaken by the Philadelphia Association for Health, Physical Education, and Recreation, and a group of cardiologists with an advisory committee of athletes.

Reveals much confusion concerning the question of the athlete's heart. Contradictory reports were presented quoting medical authorities on both sides of the question. Particularly on the question of the effects of competitive activities for those between the ages of thirteen and seventeen there were many opinions on both sides but no accompanying statistical evidence can be found on which these opinions are based.

In the committee study of 170 athletes so far only one case of extreme degree of enlargement of the heart was found and this case had a moderately advanced cardiovascular renal disease associated with high blood pressure. They caution against considering as scientific evidence any cases of heart size variation unless corroborated by x-ray films. Obviously students with a limited cardiac reserve shown, for instance, by a history of rheumatic fever or evidence of permanent damage of some part of the heart should be restricted from school team participation.

One study of ten high school cross-country runners immediately before and after a race to determine immediate effects showed: (1) The hearts of the competitors were somewhat smaller after the race than before; (2) there were no cases of cardiac collapse; (3) there were changes in the electrocardiogram which will need further study to determine whether they were due to a simple increase in heart rate or whether they reflect emotion.

The authors conclude that many more studies of this type are needed with use of precision instruments such as x-rays and electrocardiographs before doctors and physical educators can evaluate scientifically the effects of athletics

on the heart. In the meantime medical opinion considers most forms of athletics and physical education definitely beneficial.—*John H. Shaw.*

ANTHROPOMETRY

25. Keen, J. A. A study of the differences between male and female skulls. *Am. J. Phys. Anthrop.*, 8:1 (March, 1950).

The author has studied the sex differences in the skulls of the Cape colored population. After reviewing the cranial characteristics which were recognized in anthropological literature as being useful in the differentiation between the two sexes, a set of measurements was chosen with the purpose of verifying to what extent such characteristics could be relied upon. Some of the procedures proposed are new ones, as for example, measurements and an index to determine the relative sizes of the frontal and parietal bones, or the depth and extent of the infratemporal fossa. A sign not previously recognized as a differentiating character is the existence of a ridge along the upper rim of the external auditory meatus in male skulls, which is often absent in female crania.

The results of the measurements of 50 male and 50 female skulls, their respective ranges, mean standard deviations, and the critical ratios of the differences between the means are set out in tabular form. When the differential measurements for male and female crania of a particular population group are known, together with the means and standard deviations, a simple method of sexual identification can be devised. A certain number of measurements are chosen among those likely to be useful, and for each one a male range, a female range, and a neutral range are established. Each cranium can then be classified automatically. The method, when applied to the series of Cape colored skulls, gave a correct result in 85 percent of cases.—*The Wistar Institute.*

26. Tappen, Neil C. An anthropometric and constitutional study of championship weight lifters. *Am. J. Phys. Anthrop.*, 8:1 (March, 1950).

A group of championship weight lifters was measured and somatotyped. The relation of various morphological traits to performance in weight lifting was investigated by application of correlation techniques. Range of variation in the somatotype of the sample was determined. Some suggestions for further study upon the general subject of weight lifting were made.—*The Wistar Institute.*

HEALTH AND SAFETY

27. Bain, Katherine, and H. C. Stuart. Facts and figures about child health in the United States: A critical appraisal of the Academy of Pediatrics study of child health services and pediatric education. *Am. J. Public Health*, 39:9 (September, 1949).

A résumé of the results of a three-year, nationwide study covering all physicians and dentists in private practice, all hospitals caring for children and all community health services of certain categories was made. Although so large a study could only "scratch the surface," still a vast step forward has been made. The study showed a need for more doctors, more hospitals, and more community health services for children living away from cities. It was found that 61% of births in hospitals are in hospitals with no new-born nursery for sick babies separate from well ones. Only 16% of general hospitals have outpatient departments. Only 6% of children under five received service in well child clinics. Over half of the counties had not one public elementary school in which any medical examination for children was given.

One of the interesting technical contributions of the study was the index for expressing the quantity of medical care received by children. This expressed

the total volume of medical care for children in terms of care on an average day related to the child population, thus making it possible to compare the rate of children under medical care on one day in various areas.

The study also shows a striking relationship between quality and quantity of medical care and economic status.—*Harriet G. McCormick.*

28. Covalt, D. Rehabilitation of the hemiplegic patient. *N. Y. State J. of Med.*, 50:1 (Jan. 1, 1950).

In rehabilitation of the hemiplegic certain cases must be excluded from treatment, e.g., cases of malignant hypertension, advanced senility or encephalomalacia. All cases under treatment must be checked regularly to determine their ability to stand activity. The time when active rehabilitation is begun is determined by the nature of the cause of the illness. Through a carefully graded program the patient learns to become self-sufficient and independent, and, in many instances, becomes capable of returning to part- or full-time work. —*A. C. Kelly.*

29. Dean, H. W. Experiment in safety. *Safety Education*, 29:6:1 (February, 1950).

An experiment was conducted to determine the effectiveness of teaching safety by two different methods. One group (experimental) developed their own subject matter. The other (control) was taught the same subject matter by the assignment, mastery-of-the-subject method. Sixty subjects were used and grouped in matched pairs. Results were measured both by paper and pencil tests and by daily student reports of observations of behavior. Results indicated satisfactory progress by both groups and greater progress by the experimental group in safety consciousness and actions.—*Harriet G. McCormick.*

30. Halverson, Andrew W., and Edwin B. Hart. Factors affecting the stability of the vitamin A from cod liver oil in cereal feeds. *J. Nutrition*, 40:3 (March, 1950).

The vitamin A in mixed ration and ground white corn samples containing added cod liver oil was not stabilized by storage in sealed containers (gas tight) at different moisture levels. The removal of enclosed oxygen by respiration of the feed samples at higher moisture levels (10 to 15%) showed no demonstrable effect upon vitamin A preservation. Significant amounts of the added vitamin A in the mixed ration and white corn samples (without added trace minerals) were retained after several months' storage.

Approximately 60% of the initial vitamin A content of the mixed ration was still present in samples stored in the sealed and unsealed containers for two and one-half to three months at 33 to 36°C. The extremely rapid destruction of vitamin A induced by adding the trace of minerals (Fe, Cu, Co, and Mn) to an unsealed white corn sample containing added cod liver oil was largely prevented by adding the minerals in a dried gelatin-mineral mixture rather than in free form.

The experiments did not determine whether the free trace minerals were capable of exerting their usual destructive catalysis of vitamin A when feeds are stored in an atmosphere of free oxygen. The present study indicates that a solution of the problem of rancidity and vitamin A destruction in practical feed mixes depends upon the addition of the trace minerals in a form which limits their ability to contact and react with other constituents of the ration. —*The Wistar Institute.*

31. Ruegamer, William R., Clyde E. Poling, and Haines B. Lockhart. An evaluation of the protein qualities of six partially purified proteins. *J. Nutrition,* 40:2 (February, 1950).

Six protein samples distributed for collaborative study were evaluated by the rat-growth method for their relative protein qualities, and were found to be in the following order in these respects: egg albumin, whole egg powder, beef muscle, casein, peanut flour, and wheat gluten. The beef muscle preparation applied for these studies may not have been representative of beef since it gave markedly inferior results when compared to two preparations of beef muscle made in our laboratory and to two samples of raw beef.—*Wistar Institute.*

32. Scobee, R. G. Finding the child with eye problems. *J. School Health,* 19:8 (October, 1949).

Case-finding in children presents many more obstacles than case-finding in adults. Perhaps a child's grades in school are a fairly good criterion if a single one has to be picked for discovering eye problems. Eyestrain cannot be easily detected in children because they are notorious mimics. Furthermore they do not complain of poor vision because they are not aware of missing anything.

If a single criterion of poor vision must be picked, Dr. Scobee would choose visual acuity. He reports a recent study of the Adjutant General's office in connection with the Vision Committee of the Army-Navy-National Research Council which shows that from the standpoint of reliability the Snellen Chart is as good as any other chart yet devised.

He warns, however, that not all tests for visual acuity done on a Snellen Chart are good. Particularly with children, care must be taken to familiarize them with the test, the shy child must be encouraged, the testing must not be hurried, and it should be done in private if a good test is to be secured.

On the basis of 1,200 children studied in St. Louis it was found that in children who had some other condition, requiring follow-up, there was frequently a slight difference in visual acuity between the two eyes—only one line. The child with 20/20 vision in each eye was more likely to have normal eyes than one with 20/20 vision in one eye and 20/15 in the other.

Dr. Scobee noted that a one-eyed person never has headaches from eyestrain because most headaches noninflammatory in origin come from trying to use two eyes together, as a team. He summarizes case-finding in children as involving primarily three steps: (1) observing behavior and symptoms in children; (2) testing for visual acuity; and (3) checking for muscle imbalance.—*John H. Shaw.*

33. Swanson, Marie. Reasons for lack of treatment of physical defects in high school pupils. *J. School Health,* 19:7 (September, 1949).

This article is based on a study of reasons for lack of treatment of defects in high school pupils made in 1942 in the approved high schools of New York State with the exception of those in New York City, Rochester, and Buffalo.

Sixty-one percent (470) of the schools solicited replied and the blanks returned reviewed 66,871 pupils, of whom 8,201 (12.4%) were shown to have 9,636 defects still untreated (an average of 1.1 defects apiece).

The untreated defects consisted of about one-half, teeth; one-fourth, tonsils; and one-eighth, eye defects. The remainder included: orthopedic, ears and wax, nutrition, heart, thyroid, skin, hernia, nose, glands, reproductive organs, speech, and nervous system. Most long-standing untreated defects were nutrition, especially obesity, those requiring surgical treatment, and speech and hearing, in that order.

Reasons for lack of treatment were coded under 28 hearings but most of them grouped under three main headings. First were those having to do with the parents' attitude toward the child, the defect and the need for treatment, 45.1%; second, reasons concerned with lack of money, 31.7%; and third, the pupils' objection to treatment, 14.1%.

The remainder of the article dealt with suggested procedures for dealing with reasons for lack of treatment. Adult education and the seeking of cooperation by the school with community organizations and social agencies were particularly stressed.—*John H. Shaw.*

PSYCHOLOGY

34. Garrett, Harley F. A review and interpretation of investigations of factors related to scholastic success in colleges of arts and science and teachers' colleges. *J. Exper. Ed.*, 28:91-138 (December, 1939).

This study summarizes the findings of numerous investigations related to the factors which contribute to scholastic success in college. The criterion for success has been, in almost every instance, academic grades.

The five factors found most often to have predictive value, listed in order of their value, are high school scholarships, general achievement test scores, intelligence test scores, general college aptitude test scores, and special aptitude test scores. Tests of personality and character have little predictive value, although rating scales administered by principals and teachers appear to have real contributions to make in prediction.

Size of high school, salary of teachers, occupation of parents and physical characteristics of students have little or no bearing on scholastic achievement. There are no consistent differences between men and women in college success nor does the pattern of high school subjects taken have any predictive value.

The highest multiple correlations are found between combinations of high school marks and intelligence test scores; high school marks and aptitude test scores; and intelligence test scores and achievement test scores. The addition of a third variable to any of these combinations does little to improve the predictive value, and the addition of a fourth variable has no value.—*Marjorie Phillips.*

35. Lourie, R. S. The role of rhythmic patterns in childhood. *Amer. J. Psychiat.*, 105 (1949).

The rhythmic motor patterns of children are shown to be a normal phenomenon. The comparison is made between normal and abnormal infant rhythmic patterns. Investigation revealed that auditory, kinesthetic, tactile, and visual stimuli are all important components. The heart acts as a pacemaker for the rhythmic body movements. Rhythmic motor activities as a means of therapy are also covered.—*G. M. Gloss.*

36. Ryan, W. C. Review of psychiatric progress, 1948: mental hygiene in education. *Amer. J. Psychiat.*, 105 (1949).

Stress is placed upon the importance of preventive school mental hygiene if children are to develop into responsible and emotionally mature individuals. Emotional and social needs of our children can best be met through sympathetic teacher-pupil relations and rich curricula. Revisions toward the all-important goal of good mental health in schools are being effected in many communities. —*G. M. Gloss.*

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Maine (1): (No report).
Maryland (2): (No report).
Massachusetts (3): (No report).
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California (4): (No report).
Nevada: (None).
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